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Status of Atlantic salmon (*Salmo salar* L.) in Campbellton River, Notre Dame Bay (SFA 4), Newfoundland in 1999

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Abstract

The status of Atlantic salmon in Campbellton River in 1999 was determined from the number of salmon counted through a portable fish counting weir (fence) located on the main stem just above head of the tide as well as from biological data collected from the recreational fishery. The assessment was conducted in response to major management changes that were introduced in 1992 and continued into 1999. Stock status is defined in comparison of the actual egg deposition to conservation requirements. Specifically, there was a moratorium on the commercial Atlantic salmon fishery in insular Newfoundland and restrictions were placed on recreational fishing in each Salmon Fishing Area. In 1999, adult returns were 3,076 small and 493 large salmon compared to the average of 3,061 small and 333 large salmon, 1993-98. Historical records indicate that circa.1800, about 12,000 adult salmon were captured at a harvesting weir. The freshwater survival from eggs to smolt for the 1993 and 1994 year class were 0.69% and 0.71% respectively. The percent of the conservation egg requirement achieved for Campbellton River in 1999 was 326%. On average, for the period of 1993-99, Campbellton River achieved 281% of its conservation requirement. However, based on historical runs Campbellton River is only seeing just less than 30% of those past adult salmon migrations.

Résumé

On a établi quel était l'état du stock de saumon atlantique de la rivière Campbellton en 1999 d'après le nombre de saumons dénombrés à une barrière portative de comptage du poisson installée dans le bras principal du cours d'eau juste en amont de la limite extrême des eaux de marée, ainsi que d'après les données biologiques recueillies lors de la pêche sportive. L'évaluation s'inscrivait dans le cadre des profonds changements au niveau de la gestion introduits en 1992, qui s'appliquaient encore en 1999. L'état du stock est défini en termes de la ponte réelle par rapport aux besoins au titre de la conservation. Un moratoire de la pêche commerciale du saumon atlantique ayant été décrété dans l'île de Terre-Neuve, des restrictions ont été placées sur la pêche sportive dans chaque zone de pêche du saumon. En 1999, les remontes d'adultes se chiffraient à 3 076 petits et 493 gros saumons, par rapport à la moyenne de 3 061 petits et 333 gros saumons pour la période 1993-1998. Les données historiques indiquent que vers 1800, environ 12 000 adultes avaient été capturés dans une bordigue mouillée dans la rivière. Les œufs pondus en 1993 et 1994 ont affiché un taux de survie en eau douce jusqu'au stade du saumoneau de 0,69 % et 0,71 %, respectivement. Le pourcentage d'œufs nécessaire pour satisfaire aux besoins au titre de la conservation en 1999 se chiffrait à 326 % à Campbellton River. Pour la période 1993-1999, Campbellton River a satisfait à 281 % de ses besoins au niveau de la conservation. Toutefois, d'après les remontes historiques, la rivière n'est plus témoin que d'un peu moins de 30 % de ces anciennes migrations de saumons adultes.

Introduction

The Campbellton River (Indian Arm River) flows in a northeasterly direction emptying into the sea at Indian Arm, Notre Dame Bay. In total, Campbellton River has a drainage area of approximately 296 km^2 with an axial length of 40.22 km (Porter et al. 1974) and is about the average size for salmon rivers along the northeast coast of insular Newfoundland. The drainage area is also a protected water supply, which provides domestic water for the town of Campbellton. The river which is located in Salmon Fishing Area (SFA) 4 (Fig. 1), is in a very productive salmon zone which, on average, accounts for about 23 percent of all salmon landed by the recreational fishery in the province of Newfoundland (Table 1). During the early to mid-1980s, Campbellton River attracted an average of just over 2,000 rod days. However in following years, angling effort declined by 50 percent, increasing again after 1992 to approximately 1,500 rod days (Table 2). Catches in the commercial salmon fishery between 1984 and 1990 declined considerably for the island of Newfoundland and the fishery was closed in 1992. In SFA 4, the commercial catch in 1991 experienced a 64% and 47% drop for small and large salmon, respectively, when compared to the mean catches in 1984-90 (Table 3).

In this paper, we examine the status of Atlantic salmon in Campbellton River. Counts obtained from smolt and adult counting fences are used in conjunction with recreational fishery data and biological characteristic data to calculate total river returns and spawning escapements. Status of the Atlantic salmon stock is evaluated against a conservation requirement which is calculated in terms of available fluvial and lacustrine habitats.

Management Measures

In 1992, a major change was introduced in the management of Atlantic salmon. A five-year moratorium was placed on the commercial fishery in insular Newfoundland, while in Labrador fishing continued under quota until 1998 when the fishery was closed. In addition, a commercial license retirement program went into effect in both insular Newfoundland and Labrador reducing the number of licenses by 96%. Presently, 100 commercial salmon licenses are still held by Newfoundland and Labrador fishers. These measures were still in effect in 1999. All of these management measures were aimed at increasing river escapements, thus contributing to the increased numbers of upstream migrating adult salmon. Also, a moratorium on the Northern Cod Fishery in NAFO Divisions 2J and 3KL was implemented in early July of 1992 and in NAFO Divisions 3Ps, 3Pn and 4R in 1993 which should have resulted in the elimination of salmon by-catch in cod fishing gear in SFAs 1-9 in 1992 followed by SFAs 10 - 14A in 1993. The commercial cod fishery moratorium continued in 1998 with exception of a limited commercial fishery in 3Ps and recreational hand-line fishery. In 1999, fishing re-opened in NAFO Divisions 2J and 3KL with a test fishery of 9,000 t and 3Ps had a quota of 30,000 t. An ongoing cod test fishery (Sentinel Survey) takes place at various locations around the island. A study of the salmon by-catch in the inshore capelin fishery was undertaken by DFO in 1983 at several major bays around Newfoundland. The results of

this study indicated that very few salmon smolts were caught as a by-catch in this fishery (Reddin and Downton, unpublished report 1983). Therefore, it is assumed that the by-catches of the two major fisheries around the island have had little impact on salmon populations since 1991.

In the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each Salmon Fishing Area (SFA). The quota was assigned for an entire SFA and was not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught. In 1994, SFA recreational fishery quotas were eliminated. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date up to the end of the fishing season. Hook-and-release fishing was permitted throughout the fishing season. These measures remained in effect in 1997 and applied to salmon angling on Campbellton River. However, due to low salmon returns in 1997, all rivers were closed to retention as of July 28 and then on August 1st both retention and hook and release fisheries were closed which remained in effect to the end of the season. In 1998, the retention of one fish was permitted during the initial part of the fishing season until an in-season review in July was completed allowing another 3 fish to be retained, thus giving a 4 fish retention quota. In 1999, a River Classification System was introduced for scheduled rivers on the island portion of the province. Campbellton River was designated Class II which set four salmon as the season limit. Barbless hooks were mandatory.

In 1999, the fishing season in 1999 started on June 15 and ended on September 7. In 1999, due to adverse river conditions, many rivers in SFA 4 including Campbellton River were closed to fishing on July 23 and reopened on August 16. Also, as in previous years, retention of large salmon was not permitted in insular Newfoundland and hook and release fishing was reduced to two fish per day.

Methods

ANGLING FISHERY

Catch and effort data for Campbellton River as well as other rivers in Newfoundland and Labrador were collected by Department of Fisheries and Oceans (DFO) Fisheries Officers until 1996. Beginning in 1997, a License Stub Return System was used to collect data directly from anglers in all SFAs of Newfoundland and Labrador with the exception of SFAs 1 and 2 in Labrador (O'Connell et al. 1998). Data for both methods were processed by DFO Science Branch staff. Procedures for the collection and compilation of angling data are described by Ash and O'Connell (1987) and O'Connell et al. 1998.

UNRECORDED MORTALITIES

Complete understanding of all life history factors including mortality is an important part of any stock assessment (Ricker 1975). Mortalities due to fishing but not recorded as part of the catch statistics have been defined as non-catch fishing mortalities (Ricker

1976). Non-catch fishing mortalities should include those fish killed due to both illegal and legal fishing activities. Legal fishing mortalities of salmon in Newfoundland and Labrador include catches in food (First Peoples), angling, sentinel and commercial fisheries. Illegal mortalities include poaching in both the freshwater and marine environments. Illegal mortalities by their very nature are extremely difficult to quantify. An indirect method of quantifying removals by illegal means and by predators is by observation of net marks, scars and abrasions on salmon at enumeration facilities. During 1993-99, fish with visible marks were observed at Campbellton River by closed-circuit video and visual observations. These observations provide a minimum estimate of the incidence of marked fish because light conditions or minor scarring could render some marks invisible. The incidence of marks does not quantify unrecorded mortalities but does provide an indication that illegal or legal by-catches of salmon and/or predation was likely occurring at sea for Campbellton River salmon prior to their entry into freshwater. However several illegal salmon fishing charges were laid by DFO on Campbellton River in 1999.

Additionally, quantification of mortalities arising from the practice of hook and release fishing are also important for accurately assessing spawning escapement. To date, there have been no definitive hook and release mortality studies on salmon in Newfoundland. However, studies elsewhere have shown that mortality rates of hooked and released 'bright' salmon are low depending in part on the skill of the angler, method of fishing and length of time the fish are handled, length of residence of the salmon in freshwater prior to angling, and most important the temperature of the water. Recent studies in New Brunswick indicate that rates of 10% are possible (Brobbel et al. 1996; Dempson et al.1998; Anon.1998). Another source of unrecorded mortalities is from poaching above the counting fence. Due to the illegal nature of poaching no enumeration of the number of salmon caught illegally on Campbellton River is possible. However, these additional removals potentially result in a lower than indicated number of spawners. Thus, calculation of spawning escapement based on counts at the fence should be regarded as potential only.

SMOLT AND ADULT SALMON COUNTS

Standard conduit smolt and adult counting fences were installed according to the description in Anderson and McDonald (1978). The smolt fence was placed in the main stem of the river on April 29 th, 1999 just above the site of the Old Horwood Dam (same site since 1993), which was located approximately 345 m upstream from the highway bridge situated at the mouth of the river (Fig. 2). The entire fence was comprised of 38 sections, each 3 m in length, and a standard 2.1 x 2.1 m smolt trap installed across a 68 m section of the river. The substrate was mainly bedrock with large and small boulders and minor amounts of loose gravel. This site was chosen because it has a stable substrate and adequate water levels for fish passage during the smolt migration period. During the smolt run, the trap was checked and fish released on a regular 2-hour basis from 0600 hrs to 2230 hrs. Also, at each trap check several environmental parameters were measured, i.e. water temperature, air temperature, and water level. During the peak smolt run, two 30 cm openings were made in the fence on each side of the smolt trap by removing several conduit. A plywood board, light in colour, was positioned on

the river bottom to count fish passing through the fence on their downstream migration. The smolt fence was removed on June 10 th, 1999. In previous years the tail end of the smolt migration was enumerated via the adult fence after the smolt fence was removed. This procedure is followed when the downstream smolt migration overlaps with the upstream adult salmon run. However in 1999 the smolt migration was completed before the start of the adult migration due to early spring conditions resulting in the early run of smolts. Therefore the smolt enumeration is considered a complete count.

The adult fence was situated just below the Old Horwood Dam, approximately 212 m from the mouth, on a bedrock substrate in a 25 m wide section of the river (Fig. 2). The fence had 16 sections (3 m long) and a 2.1 x 2.1 m adult trap, and was operated from May 29 to September 14, 1999. A tunnel with a video camera system (VHS format) was installed in the trap giving a positive overhead view of salmon moving upstream. Videotapes were reviewed the next day to count salmon and the count verified by a second viewing. If necessary, a third viewing was made to resolve any discrepancies. This system has proven to be very successful since first installed in 1993 and has allowed salmon to move upstream through the fence on a continuous basis, especially during the night when visual monitoring becomes more difficult. Use of the camera system seemed to move salmon through the fence more quickly than would have been the case with a standard fish trap. Also, during daylight hours, a 0.5 m section of the fence next to the trap was opened into a 1 x 2 m sampling trap and monitored manually to further facilitate the upstream migration of salmon or to retrieve archival tags from adult salmon and biological sampling. This manual counting of salmon at the fence site from 1993 to 1999 has accounted for 40-50% of the upstream migrating salmon passing through the fence. All salmon counted were sized into two categories, viz. small salmon less than 63 cm and large salmon 63 cm or greater. This was achieved by placing parallel marks 63 cm apart on the floor of the trap/counting device.

SEA SURVIVAL & PREVIOUS SPAWNERS

Sea survival was determined from the number of returning adults in year n+1 and the number of smolts of the preceding year n. The adult salmon counted at the fence consisted of several year classes including salmon spawning for the first time as grilse and salmon that had previously spawned. Thus, sea survival with upstream migrating previous spawners removed from small salmon counts will provide a more accurate measure of sea survival when linked with smolts from the previous year. The number of previous spawners in the returning adults was determined by mark-recapture. The proportion of downstream migrating previous spawners (kelts) tagged from 1994 to 1999, was 33.2%, 23.9%, 24.6%, 15.0%, 31.1% and 30.8%, respectively. Previous spawners were marked with Floy T-bar anchor tags with different colors and positions on the dorsal fin for each year. Year of tagging could then be identified by tagging position on the video screen of the counter or manually as they passed through the fence. Counts of small and large salmon were then adjusted for the number of previous spawners based on the ratio of tagged to untagged fish in the returning run and the number of outgoing kelts originally tagged.

ENVIRONMENTAL DATA

During field operations, environmental data were collected at both fence sites. Water temperatures were recorded by a Hugrun thermograph set at 1 m from the surface at the fence site. Cloud cover, relative water levels, weather conditions and air temperatures were also recorded. Marine temperatures were obtained with a Hugrun thermograph set just off Comfort Cove in 30 meters water depth. Water temperatures have been collected at this location by DFO since 1974. Also, a thermograph was set in1995 and 1999 at 8 meters near the mouth of Campbellton River, Indian Bay.

EXPLOITATION RATES

Exploitation rates for the angling fishery were derived based on the number of small salmon counted at the fence and the number of salmon reported to have been caught by the angling fishery. Estimates of fishing mortality by hook and release were included.

BIOLOGICAL CHARACTERISTICS

Biological characteristics were collected from salmon caught in the angling salmon fishery on the Campbellton River from 1992-99 by staff at the counting fence and post-secondary students hired by HRDC through the Challenge Program, under the guidance of DFO technical staff. These students were responsible for collection of information on fork length, weight, sex, scales and ovaries. The biological characteristics on percentage female, mean weights, and fecundity from the sampling program were used to estimate egg depositions in 1993 to 1999 and used to convert conservation requirements in eggs to spawning requirements in number of fish. Also, the percent of the conservation requirement egg deposition achieved was assessed.

Fecundity was determined from ovaries collected from the recreational fishery. Ovaries were stored in Gilson's fluid until transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both small and large salmon was 2,100 eggs per kg and was derived from mean of 78 samples taken in Campbellton River, 1993-95.

CONSERVATION REQUIREMENTS

The accessible parr-rearing habitat for Campbellton River is 5,960 units (a unit being 100 m^2) of fluvial habitat and 4,037.3 ha of pond habitat (Reddin and Downton 1994). The ratio of lacustrine to fluvial habitat of 67.74 is lower than the mean of 87.11 for other SFA 4 rivers (O'Connell and Dempson 1991). However, smolt lacustrine production levels may be much higher than 7 smolt per hectare since many of the ponds are very shallow, making them more suitable for smolt rearing. Reddin and Downton (1994) derived potential smolt production for Campbellton River of 46,141 smolts by multiplying the amount of fluvial and lacustrine habitat by production parameter values of 3 smolts per unit (100 m^2) of fluvial habitat and 7 smolts per ha of lacustrine habitat (O'Connell et al. 1991).

The conservation requirements for the Campbellton River of 2,916,126 eggs was derived using egg deposition rates of 240 eggs per 100 m^2 for fluvial parr rearing habitat (Elson 1957) and 368 eggs per hectare for lacustrine habitat (O'Connell et al. 1991; Reddin and Downton 1994). Although these values may be habitat and river specific for systems from which they were derived, they are used to represent a threshold or danger zone to be avoided (O'Connell et al. 1991). Conservation requirements in eggs were converted to adult small salmon by the following formula:

(2,916,126 / (Proportion female * mean weight * fecundity))

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

The egg deposition was based on the number of spawning adult female salmon and biological information collected from the angling fishery, 1992-99.

Total river returns

Total river returns (TRR) were calculated as follows:

(1) $TRR = RC_b + HRM_b + C$

where,

RC_b = angling catch below counting fence

HRM_b = hook & release mortalities below counting fence (0.1 of hook & releases)

C = count of fish at counting fence

Spawning escapement

Spawning escapement (SE) was calculated as the difference between the number of fish released from the counting fence (FR), the recreational catch retained above the fence (RC_a) and hook and release mortalities above the fence (HRM_a).

(2) $SE = FR - RC_a - HRM_a$

Egg deposition

Egg deposition (ED) was calculated separately for small and large salmon and then summed as follows:

(3) $ED = SE \times PF \times RF \times MW$

SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. eggs/kg)
MW = mean weight of females

O'Connell and Dempson (1997) reported that unpublished evidence exists demonstrating that atresia (non-development of eggs) occurs to varying degrees in insular Newfoundland salmon. This phenomenon has also been reported in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Therefore, fecundity values should be regarded as potential values. Since conservation requirements are based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

ACCURACY OF EGG DEPOSITIONS

The accuracy of egg depositions is very important as it describes the status of the salmon stock in Campbellton River. Accuracy was investigated in two ways. First, by a simulation exercise which investigated the variability around several parameters and the effect of this variability on egg deposition rates. In the section on egg depositions, only the numbers of small and large salmon returning to Campbellton River in 1993-99 were known with certainty. To account for some of the uncertainty in other parameter values used to determine potential egg deposition, we assumed a variation of ±10% around the fecundities, percentage females and mean weights of both small and large salmon components and recalculated the estimated egg deposition using 1000 realisations from a uniform distribution.

The second way of investigating accuracy of egg deposition values was by recalculating the annual egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. The same equations are used for both estimates. If the number of samples are adequate to define biological characteristics of either group then the egg depositions from the two methods should be similar. Egg depositions from kelts are based on the number of eggs per cm whereas eggs per kg are used for the upstream migrating salmon.

SALMON POSTSMOLTS

Salmon postsmolts that return to spawn after only a couple of months at sea instead of at least a full year occur in some Newfoundland rivers. Beginning in 1995, a 35 cm mark was installed in the tunnel of the video counting chamber of the adult counting fence in Campbellton River to enable enumeration of this class of salmon. Verification of the age class of these postsmolt salmon was done by scale analysis. Data are available for 1995-99.

EFFECT OF MORATORIUM

The effects of the commercial salmon fishing and cod fishing moratoria were examined through the time series of egg depositions and resulting smolt production, sea survival rates, and conservation requirements met. Although the effects of the commercial salmon and cod moratoria cannot be separately estimated, both continued in 1999 and would have impacted on the spawning escapement beginning in 1992. The goal of the commercial salmon fishing moratorium was to increase spawning escapement while the goal of the northern cod fishery moratorium was to protect and stimulate recovery of cod stocks to previous numbers. Because salmon are caught as a by-catch in non-salmon gear, especially cod traps, the effect of the cod moratorium would be to increase spawning escapement.

The time series of data for Campbellton River is seven years (1993-99) which restricts analyses that compare data from before (prior to 1992) to during (post 1991) the moratorium period. However, because smolts ages from Campbellton River are mainly 3^+ and 4^+ (96% on average) we can examine the smolt output of several year classes of spawners from before and during the moratoria as follows:

Category	Year class (spawners)	Smolt years
Before	1989	1993 & 1994
Before	1990	1994 & 1995
Before	1991	1995 & 1996
During	1992	1996 & 1997
During	1993	1997 & 1998
During	1994	1998 & 1999

Results

ANGLING FISHERY

In 1999, the angling salmon fishery on Campbellton River recorded a total catch of 258 small salmon and 12 large for a total of 270 (Table 2). Of these, 69 small and 12 large salmon were hooked and released. In 1996, 31 large fish were reported as hooked and released which is the highest value since 1975. While for small salmon the highest value occurred in 1998 with 281 fish recorded. The higher annual catches since 1992 are attributed to increases in the salmon returns as a result of the closure of the commercial fishery and also due to increased angling effort.

During the adult fence operations, the river was closed to angling for 43 m above the counting fence at the Old Horwood Dam site and from below the fence to saltwater. However, a section of the river referred to as the "V" located at the Old Horwood Dam that received most of the fishing pressure on the lower section of the river in years previous to the installation of the counting fence remained open. The next site of

extensive angling was centered around the lower part of Second Pond and resulted from an upgraded forestry road and new bridge which were constructed in 1992 and provided easier access to this part of the river. The main stem between Fourth Pond and Indian Arm Pond and the lower portions of Indian Arm Brook and Neyles Brook were also popular fishing sites. Also ongoing extension and new logging roads into the river has increased accessibility which should see an increase in the angling pressure.

Water temperatures and levels in 1999 were generally good for the first part of the angling season until mid-July which facilitated upstream migration. However, after mid-July to mid-August very low water levels and high water temperatures occurred that restricted salmon at sea moving into the system. During this period many salmon were noted jumping in the estuary just outside the bridge and it wasn't until a heavy rainfall on August 15 that these fish entered the river. During a 5-day period after the rainfall 14% of the total run for the season entered the river. Similar water levels and temperatures occurred in 1997 and reflected the same migration pattern.

UNRECORDED MORTALITIES

At the Campbellton River fence, visible scar marks were recorded on a daily basis. Overall in 1999, there were 4.12% or 147 of the 3,569 upstream migrating Atlantic salmon with visible body scarring. These marks were observed mainly on the head of the fish, which generally is consistent with that expected from small mesh nets, i.e. used to catch herring. Because the Campbellton counting fence is only 0.25 km from the sea, these marks had to have occurred sometime before the salmon entered freshwater. In 1994, 1995, 1996, 1997, and 1998, 6.2%, 5.0%, 4.3 %, 4.3% and 5.6%, respectively of the upstream migrating salmon had marks. Also, during the seven-year period of sampling angled salmon, several fish had very distinct scarring that might be attributed to predation by seals. It is concluded that there is some mortality at sea due to natural and illegal fishing, although the overall magnitude is unknown and very difficult to quantify.

SMOLT AND ADULT SALMON COUNTS

In 1999, a total of 47,256 smolts and 1,857 kelts passed through the downstream fence along with several other species of fish such as smelt and brook trout (Table 4). The peak of the smolt run occurred in standard week 21 (May 21 - 27) which accounted for 35.1% of the total migration (Table 5). Excluding the early year of 1996 and the late year of 1997 a shift towards earlier migration has occurred since 1997. Of the seven years for which smolt counts are available, 1999 smolt run was the fourth highest in number, just below the 1993-98 mean. The 1996 smolt run was the earliest to start and 1997 was the latest (Fig. 3). The difference in run timing for 1996 and 1997 may be attributed to spring conditions, in particular water temperature, which seem to have a direct effect on timing of smolt migration. The smolt run doubled from 31,577 in 1993 to 62,050 in 1997 and decreased by 18.1% to 50,441 in 1998 and 23.8% for 1999. The overall mean smolt count for 1993-99 was 47,296. This value is very close to the potential smolt production value of 46,141.

In 1999, a total of 3,076 small and 493 large salmon were counted as they passed upstream through the adult fence (Table 6). The first adult salmon was counted on 30th May and the last fish was counted on 14th September. On average, weeks 25, 26, and 27 combined accounted for about 56.7% of the upstream migration, 1993-99 (Table 7). In 1998, week 25 accounted for 51% of the total run, which is the highest percent to occur in any one standard week during the counting fence monitoring program. This may be attributed to very favorable water conditions that occurred throughout the upstream adult migration for that year. Large salmon returns in 1999 represented 13.8% of the run. The peak run for large salmon occurred after the peak for small salmon for Campbellton River from 1993-99. Generally, these large fish mainly represent returning kelts.

In 1999, the adult counting fence was in operation from 29 May to 14 September and represents a complete upstream count for adult salmon (Table 7). However in 1996, the fence operation stopped as of August 20 due to reductions in funding. Based on small salmon counts from 1993-95, the percent entering after 20 August ranged from 0.6 to 0.8%. If the ratio after August 20 from previous years is applied to the 1996 count, then there may have been 18 to 27 small salmon entering the river after 20 August, 1996. For large salmon, the percent entering after 20 August ranged from 1.8 to 3.7% which may have resulted in 10 to 21 large salmon entering the river after 20 August, 1996. Because these numbers are only a small proportion of the total, the adult run for 1996 is considered complete.

Both smolt and adult runs at Campbellton River were considerably earlier in 1996 than in either of the other six years (Figs. 3&4). This was possibly the result of the warmer spring conditions that prevailed in 1996. Consequently, the number of adult salmon that may have entered after the 20 August may be lower than calculated from the run timing that occurred later in previous and subsequent years. Before the adult fence was removed on 20 August, the river downstream from the fence was checked visually for any adult salmon and none were observed. Therefore, it is assumed that a complete upstream migration count of adult salmon was achieved in 1996. This visual check was also done for 1999, and 5 salmon were counted below the fence.

SEA SURVIVAL AND PREVIOUS SPAWNERS

Smolt-to-adult survival (uncorrected) for the 1998 smolt class from Campbellton River (SFA 4) was 6.10% (Table 8, Fig. 5). Estimates of smolt-to-adult survival were 9.05%, 7.28%, 8.08%, 3.38% and 5.28%, respectively for the 1993, 1994, 1995, 1996 and 1997 smolt classes. Calculations to derive these values are summarized in Appendices 1 to 6. These values are overestimates of survival from smolt to 1SW (grilse) salmon because some of the small salmon migrating upstream are in fact previous spawners that survived from grilse that migrated upstream in previous years. Kelts tagged passing through the downstream smolt fence allowed for correction of the number of previous spawners in the upstream run and calculation of sea survival rates for 1SW salmon excluding previous spawners. The results of the tagging study indicated that 33.4% of the small salmon returning to Campbellton River in 1997 were previous spawners (Appendix 4). For the 1997 smolt class, the corrected survival rates after removal of

previous spawners was 2.25%, which was the lowest percent during the fence operation from 1993-99 (Table 8). Average sea survival for salmon returning to Campbellton River was 5.6%, 1994-99. Over-wintering survival of salmon spawning in Campbellton River has averaged about 68.3% from 1994 to 1999. Due to the late installation of the counting fence in 1998, many kelts had probably already migrated out of the system and were not included in the count. Thus, survival rates had to be derived from average of rates of previous years. The mean proportion of the adult run consisting of previous spawners for 1994-99 is estimated to be 35.51%. This number may be slightly higher due to tagged kelts that were either taken at sea or migrated to other river systems. Returns from 2,906 tagged kelts from 1994 to 1999 indicated that that 1.59% kelts strayed to other rivers and 2.12% were caught at sea (Appendix 8). One salmon, tagged at Campbellton River on May 9, 1999 at 47cm in length was gill netted at Kangamiut, West Greenland at 60 cm in length on September 15, 1999. In 1999, previous spawners made up 21.4% of the upstream adult run (Appendix 6).

Analyses of the data from previous years indicated that kelts returned to Campbellton River after an average of 65 days at sea. The return rates for previous spawners from 1994 to 1999 were 25.58%. 34.83%, 39.38%, 39.00%, 33.21% and 41.07%, respectively (Appendices 1 to 6).

ENVIRONMENTAL DATA

Water temperatures in Campbellton River for 1999 ranged from a low of 0 °C on April 7 to a peak of about 26.8 °C on August 3 (Fig. 6). Both water temperatures and levels stayed within a desirable range for salmon during May to mid-July; however after mid-July to the end of August, conditions were less favorable to upstream migrations in 1999, as in some other years (Fig. 7). Mean water temperatures for 1999 were higher when compared to the mean temperatures from 1993-98 (Fig. 7). Unfavorable freshwater conditions (low water levels and high water temperatures) which are becoming more and more common during summer months in Newfoundland can act as a barrier to salmon migration. During these periods, some salmon will remain in the estuary only ascending the river after sufficient rainfall has ameliorated freshwater conditions. These migration patterns were quite prevalent in 1997 and 1999. Estuary temperatures for 1999 located near the mouth of the river at a depth of 8 meters from May 3 to Sept.15 ranged from –0.1 to 19.5 °C (Fig. 8). Maximum and minimum air temperatures were 34.0 and -1.2 °C between April 29 to September 14 (Fig. 9).

EXPLOITATION RATES

In 1999, a total of 3,569 small salmon passed through the counting fence and there was a catch of 189 small salmon retained by the angling fishery above the fence. Although the river was closed to angling below the fence to salt water, fish were taken by illegal means. This is consistent with previous years; however, it is assumed that the number removed illegally represent only a very small proportion of the total run. The exploitation rate in 1999 was 6.1% for small retained salmon (95% CI=4.6-7.6%). Overall, exploitation has been increasing on Campbellton River, 1993-98. Exploitation on small salmon (retained only) peaked in 1996 at 14.4% then declining to 6.1% in 1999.

In 1999, low water conditions resulted in the river being closed which reduced exploitation. In 1998, the exploitation rate for small released salmon was highest at 20%. Exploitation on the total population has increased by about 50% from 1993 to 1996 and then declined. Exploitation rates are shown in the following text table:

Year	Small retained	Small ret. + rel.	Large released	Total
1993	7.9%	10.5%	0.0%	10.1%
1994	11.9%	12.0%	0.5%	11.3%
1995	12.9%	14.5%	0.5%	13.6%
1996	14.4%	17.3%	5.5%	15.6%
1997	12.9%	16.3%	2.8%	14.4%
1998	11.5%	20.0%	2.0%	18.9%
1999	6.1%	8.4%	2.4%	7.6%

BIOLOGICAL CHARACTERISTICS

The river ages of smolts sampled at the counting fence in 1993-99 ranged from 2 to 6 years with the 3 and 4 river years representing the predominant classes and accounted for 95.9% (Table 9). From 1993 to 1997, river age 3 smolts represented the highest percentage and then there was a switch to 4 in 1998 and 1999. More important is that the percent of river age 3 smolts was increasing from 1993 to 1995 and then started to decline during 1996-98. In 1998 and 1999 river age 4 smolt became the dominant class increasing to slightly over 50% of the run.

Approximately 0.5% of the smolt migration was sampled each year during 1993-99, which represents an overall total of approximately 1,693 fish. The 1999 smolt mean whole weight of 48.8 g was slightly higher for female smolt than the 48.3 g for males, whereas the males were 0.3 mm longer in length (Table 10). The overall 1993-99 mean fork length and whole weight for both sexes was 173.0 mm and 48.6 g with a mean river age of 3.48 years. Smolts sampled in 1993 produced the highest mean fork length and whole weight at 186.3 mm and 60.5 g.

From 1992 to 1999, 295 adult salmon were sampled from the recreational fishery and a further 56 salmon were sampled at the counting fence for a total of 351. Overall mean fork length of grilse was 53.11 cm with a mean whole weight of 1.57 kg and river age of 3.31 years (Table 11). Twenty-five (10%) of the small salmon that were sampled during 1992-98 had previously spawned. Also, three fish were sampled that returned to freshwater in the same summer that they went to sea as smolts. River age of salmon sampled in the angling fishery and at the counting fence show a very high percentage of river age 3 salmon and a much lower percentage of river age 4 than the smolt sampling (Table 12). The reasons for these differences are unclear but may be related to differential survival and some years with low sample sizes from the angling fishery. A 2nd order polynomial was used to relate fork length and whole weight for adult salmon caught in the recreational fishery and gave an R^2 of 0.81 (Fig. 10).

The biological characteristics of salmon sampled in the recreational fishery and at the counting fence are used to annually determine the number of eggs deposited in the system by female spawners and the percent of the conservation requirement met. The percentage of female salmon sampled from the recreational fishery in 1999 was 73.9% (Table 13). The mean weight for small female salmon was 1.68 kg (n=32 and sd=0.37). Because of low sample sizes in 1998 of 21 small salmon, the average percent female and whole weight, from 1993-98 were used to calculate the percent of the conservation requirement met for that year. There were no samples for large salmon available from Campbellton River due to the mandatory release of large salmon in the recreational fishery introduced in 1984, except for samples taken at the adult trap. Default values for mean weight and the percentage of large salmon that are female are 3.13 kg and 76.9%. These default values were derived from several rivers in SFA 4 (O'Connell et al. 1996).

CONSERVATION REQUIREMENTS AND POTENTIAL SMOLT PRODUCTION

The estimated conservation requirements for Campbellton River in terms of eggs as well as adult salmon were estimated as follows:

	Lacustrine	Fluvial	Total
Accessible habitat	4037.3 ha	5,960 units	-
Eggs (No. x 10^6)	1.486	1.430	2,916,126

Conservation requirements converted to numbers of small salmon (Reddin and Downton 1994):

$$= \frac{2{,}916{,}126 \text{ eggs}}{(\%\text{ female} * \text{mean wt female} * \text{fecundity})}$$

$$= \frac{2{,}916{,}126}{(0.739 * 1.68 * 2100)}$$

= ~ 1480 small salmon

Estimated potential smolt production are as follows:

Fluvial smolt	= 3 smolts/unit * 5960 units	= 17,880
Lacustrine smolt	= 7 smolts/ha * 4,037.3 ha	= 28,261
Total potential smolt production		= 46,141

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

Total river returns

In 1999, there were 3,076 small and 493 large salmon returning to Campbellton River (Table 14).

Spawning escapement

In 1999, there were 2,880 small and 492 large salmon potentially spawning in Campbellton River (Table 14).

Egg deposition

In 1999, egg deposition on Campbellton River was $9.503 * 10^6$ the highest since 1993. Thus, 326% of conservation requirements in eggs were achieved in 1999, an increase of 61.3% from 1997, and 15.6% higher than the potential egg deposition obtained over the previous six years mean (1993-98). Table 14 summarises updated information on egg deposition at Campbellton River for all years in which fish counting fences have been operated.

Freshwater survival from eggs to smolt is available for the 1993 year class. Freshwater survival was estimated by dividing the egg deposition of $9.077 * 10^6$ in 1993 into the smolt count of 2 year olds in 1996, 3 year olds in 1997, and 4 year olds in 1998. Freshwater survival was 0.69%. The egg deposition for 1994 was $6.961 * 10^6$, using smolt age counts from 1997 to 2000 for year classes of 2-5 river age smolts produced an estimated survival of 0.71%. The smolt count for river age 5s in 2000 used the mean composition of smolts from 1993-99.

ACCURACY OF EGG DEPOSITION ESTIMATES

In determining egg deposition in the previous section, only the numbers of small and large salmon returning to Campbellton River in 1999 were known with certainty. Campbellton River would have attained its conservation egg requirements at all egg deposition levels in 1999 (Figs. 11 & 12). At the 50th percentile, 9,849,734 eggs were deposited which represents 325% of conservation requirement of 2,916,126 eggs based on this level of variation. The corresponding 5th and 95th percentiles of the percentage of conservation requirement met varied from 240 to 318%.

The precision of annual egg deposition values was examined by deriving egg depositions from the biological characteristics of the upstream migrating adults sampled in the angling fishery compared to that derived from downstream migrating kelts measured at the smolt fence in the following year. Comparison of values derived on fresh run versus kelts shows 311% versus 304% in 1993, 239% versus 220% in 1994, 279% versus 256% in 1995, 304% versus 256% in 1996, 200% versus 185% in 1997, and 311 versus 281 in 1998 (Table 15 a & b). Because the percentage of conservation requirements achieved is always slightly higher when based on fresh run salmon suggests there may be a tendency to overestimate rather than underestimate the percent of conservation requirements achieved. However, the similarity of the two values suggests that the tendency to overestimate is small.

SALMON POSTSMOLTS RETURNING TO FRESHWATER

Stocks of Atlantic salmon exhibit various life history patterns including several alternate strategies. The entire life cycle can take place in freshwater; they can start life in the river, then migrate between river and estuary; they can migrate between river and estuary and then go to sea; or they can have the more typical anadromous life cycle of going to sea for one or more years before returning to freshwater (Power et al. 1987). In Newfoundland and Labrador, salmon migrate to sea at two to seven years of age then return to freshwater after spending at least one or more years in the sea. Salmon that have spawned one or more times after one or more years in the sea are also quite common. As evidenced by scale reading of a few salmon sampled that were caught by anglers or at enumeration facilities, a small number of salmon exist in Campbellton River that spend only a couple of months at sea before returning to freshwater. Because they do not spend a full year at sea, these salmon are typically very small being less than 40 cm fork length. Also, as they are uncommon the salmon nomenclature does not have a separate name for this life stage and they would be labelled as postsmolts (Allan and Ritter 1977). However, in the context of this report, they are referred to as precocious postsmolts.

In 1995, anglers observed for a number of rivers, e.g. Southwest Brook in Bay St. George, a high number of very small salmon migrating upstream. In 1993 and 1994, a few very small (<40 cm) salmon were observed at the counting fence ascending Campbellton River. In the spring of 1994, several of these small salmon were sampled as kelts descending through the smolt counting fence. In total, out of 907 kelts sampled there were four or 0.4% that had not completed a full year in the sea. Another 12 or 1.4% of the kelts had no complete sea year but showed two or more spawning marks. Overall, the proportion of the run that could be labelled as postsmolts remains a relatively minor component of the run.

In 1995, 13 salmon of approximately 28-40 cm in length were observed ascending through the Campbellton River counting fence. The total upstream run was 13 postsmolts, 3,035 small and 218 large salmon; thus, the upstream run consisted of 0.4% postsmolts. In 1998, the number of small salmon less than 40 cm was 51 fish and represented 1.6% of the small salmon at the counting fence. Four of these small fish

were sampled at the adult fence and all indicated incomplete sea year before returning to the river to spawn (precocious post smolts). In 1999, 83 precocious postsmolts were counted through the counting fence and represents 2.33% of the total run. Generally, these fish are observed in the latter part of the upstream migration of adult salmon.

EFFECTS OF MORATORIA

The smolt counts and the age information from the smolts as shown in Table 8a was organized as follows for the 3 and 4 river year classes:

Category	Year class (spawners)	Number of smolts		
Before	1989	15,631 & 12,620	=	28,251
Before	1990	25,931 & 13,805	=	39,736
Before	1991	24,774 & 20,050	=	44,824
During	1992	34,975 & 24,547	=	59,522
During	1993	35,685 & 25,009	=	60,694
During	1994	22,658 & 24,559	=	47,217
During	1995	21,766 & (4+ smolt for year 2000)		

The pre-moratoria year classes of 1989-91 produced on average 37,604 smolts; while moratoria year classes of 1992-94 produced on average 55,917 smolts. The difference between pre- and moratoria smolt production is 18,207 for an increase of 48.4%. This 48.4% percent increase in smolt production may have come about due to an increase in spawning escapement due to the moratoria or were possibly due to productivity increases in freshwater. For Campbellton River, the spawning escapement prior to 1993 is unknown. It should be noted that 3^+ smolts in 1997-98 which also come from moratoria-year spawning escapements has declined to 22,658 and 21,766 which is similar to smolt production of 3^+ from before the moratoria. Adult returns of small salmon from the 1993-95 smolt classes ranged from 2,857 to 3,208 with an average of 3,033 while adult returns from 1996-99 smolt classes were 1,975, and 3,275 and an average of 2,884. Thus, returns have actually declined by 149 fish or 4.9% for smolt classes from pre-moratoria and moratoria. This decline in adult returns occurred in spite of increased smolt production and seems to be directly related to sea survival which has gone from an average of 6.8% for the 1993-95 smolt classes to 4.1% for the 1996-98 smolt classes. The percent of conservation requirements met for Campbellton River from 1993 to 1999 ranged from 200% to 326% assuming that all fish minus those dead from angling spawned (Table 14). Thus, the high number of adult returns is being maintained by the high smolt production levels. Therefore, benefits from the moratoria on commercial fishing have not yet followed through to adult returns.

Discussion

Taylor (1985) discussed the historical catch record for many rivers in Newfoundland and Labrador. He states that the relatively high Atlantic salmon abundance in the Campbellton River made it valuable to the Beothucks and Europeans alike. The earliest catch record specific to Campbellton River indicates that a John Ginn landed 90 tierces of salmon on or about the year 1816. Because the early European settlers fished by placing a weir across the entire river and because there was no coastal gillnet fishery, these catches are an approximation of total salmon production of Campbellton River when it was in a pristine state. The 90 tierces converts to 18,400 kg using the conversion factors of Taylor (1985). This weight of fish converts to about 12,000 salmon if the mean weights of 1993-96 period are used. The highest count in the 1993-99 period is 4,146 or about 30% of that which Campbellton River may have produced when it was in a more natural state prior to heavy exploitation in commercial marine fisheries.

At the conservation requirement of 1,480 spawners, it is expected that about 48,000 smolts would be produced by Campbellton River. At an average sea survival rate and proportion large salmon, 48,000 smolts could produce about 4,600 adult salmon. If Campbellton River still has similar freshwater habitat to that present in 1816 then perhaps the difference between the 4,600 adult salmon produced at conservation requirements and the 12,000 it produced in a more virgin state is it's maximum production. Since the percent of the conservation requirement achieved on average for Campbellton, 1993-99 is about 281%, it would be interesting and potentially very informative to monitor adult returns in future years so that a stock recruit relationship could be developed specifically for Campbellton River.

For Campbellton River, there was no detailed habitat survey available (Porter et al. 1974). Thus, the habitat values given in this paper should be regarded as preliminary and will be subject to further review. The Campbellton River watershed has had extensive logging activity in the past, especially in the early 1900's when a 400 m long, 10 m high dam was erected by the Horwood Lumber Company near the mouth of the river to divert water into a 350 m rock-cut channel to run a pulp mill and hydro plant. At this time, the Horwood Lumber Co. had timber rights to 596 km^2 and used the river as a means to float logs to the mill. However, this operation was short lived since the dam broke in 1916 and the company went into bankruptcy. Extensive logging continued in and around the Campbellton River watershed up to 1966 when 22 small dams were removed by Price (Nfld) Ltd. under the supervision of the Department of Fisheries and Oceans. The structures from these historical logging activities are still visible in the remains of dams and tree trunks scattered at various points along the river. The remains of several dams located on the Crooked Brook tributary, which empties into Second Pond, still pose a partial obstruction to migrating salmon during low water levels. In 1961, the upper watershed near Shirley Lake and Silt Lake was completely destroyed by fire, which only now has returned to normal forest growth. Although the river is no longer used to drive logs to the sea, logging still continues over the network of roads built specifically for that purpose. The overall effects of these logging activities on the production of salmon in the system are unknown.

Since the habitat in Campbellton River has not been completely surveyed the conservation requirement may be an over- or under-estimate. The total number of adult salmon spawning in 1999 resulted in an egg deposition that was 326% over conservation requirements. It was noted during the helicopter survey that many of the spawning areas on the main stem were located between relatively small and shallow ponds. These shallow ponds may provide for an optimal utilization of rearing habitat and a higher rearing capacity may result. Therefore, caution must be used when referring to conservation requirements until a full habitat survey is completed.

For Campbellton River, the highest smolt production of 62,050 in 1997 is 134% above the calculated potential smolt production of 46,141. The modal smolt age for Campbellton River salmon is 4 years and thus, the 1999 smolt run is derived mainly from adults that spawned in the fall of 1995. For most Newfoundland rivers, spawning escapements were the lowest on record in the period 1989-91 (Dempson and O'Connell 1993). Escapements on northeast coast Newfoundland rivers increased in 1992 with the beginning of the commercial salmon fishing moratorium. Consequently, smolt production stemming from spawning escapements in the post-moratorium years may be much closer to this potential figure. Although salmon returns to Campbellton River may be the fourth highest since 1993, the survival rate of smolt to adult is considered low at 5.03% when compared to rates prior to 1997.

Assumptions associated with the parameter values used to calculate the conservation spawning requirement have been discussed previously by O'Connell et al. (1991), O'Connell and Dempson (1991), O'Connell and Ash (1994) and will not be dealt with in detail here. The comments in O'Connell and Ash (1994) on further substantiation of parameter values for calculations related to egg deposition apply as well to Campbellton River. Also, it should be kept in mind that inaccuracies in catch statistics, losses to due poaching, losses due to hook-and-release mortality, and losses from natural mortality will potentially reduce spawning escapement.

In conclusion, due to the maintenance of strong adult returns in 1993-99, the percent of conservation requirements being met on Campbellton River remains high in spite of lower than average sea survival in the last two years. Benefits of increased spawners released from commercial fisheries due to commercial fisheries moratoria, have not been fully realized, although increased smolt production has maintained strong adult returns.

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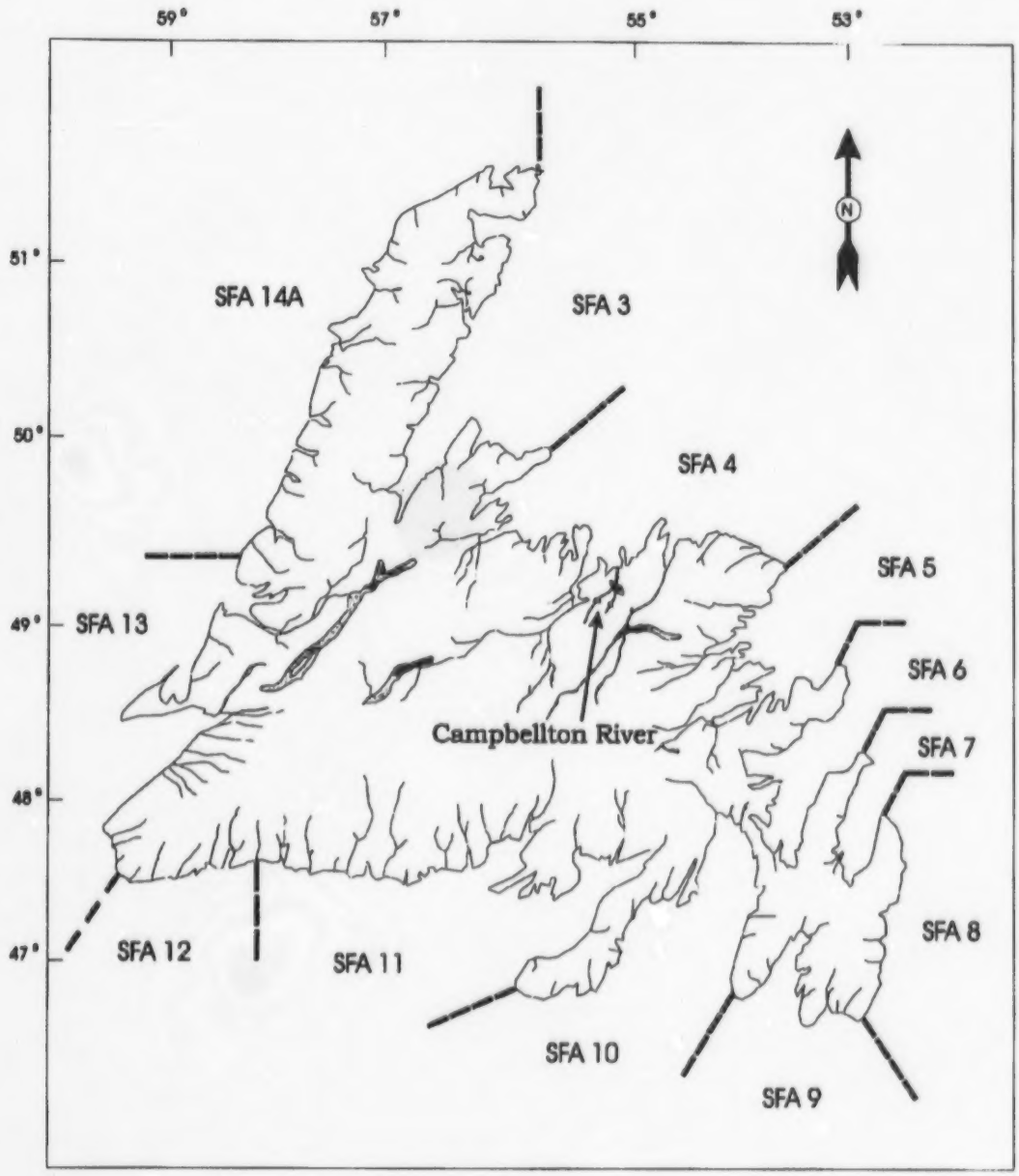

Figure 1. Salmon Fishing Areas on the Island of Newfoundland with reference to the the Campbellton River.

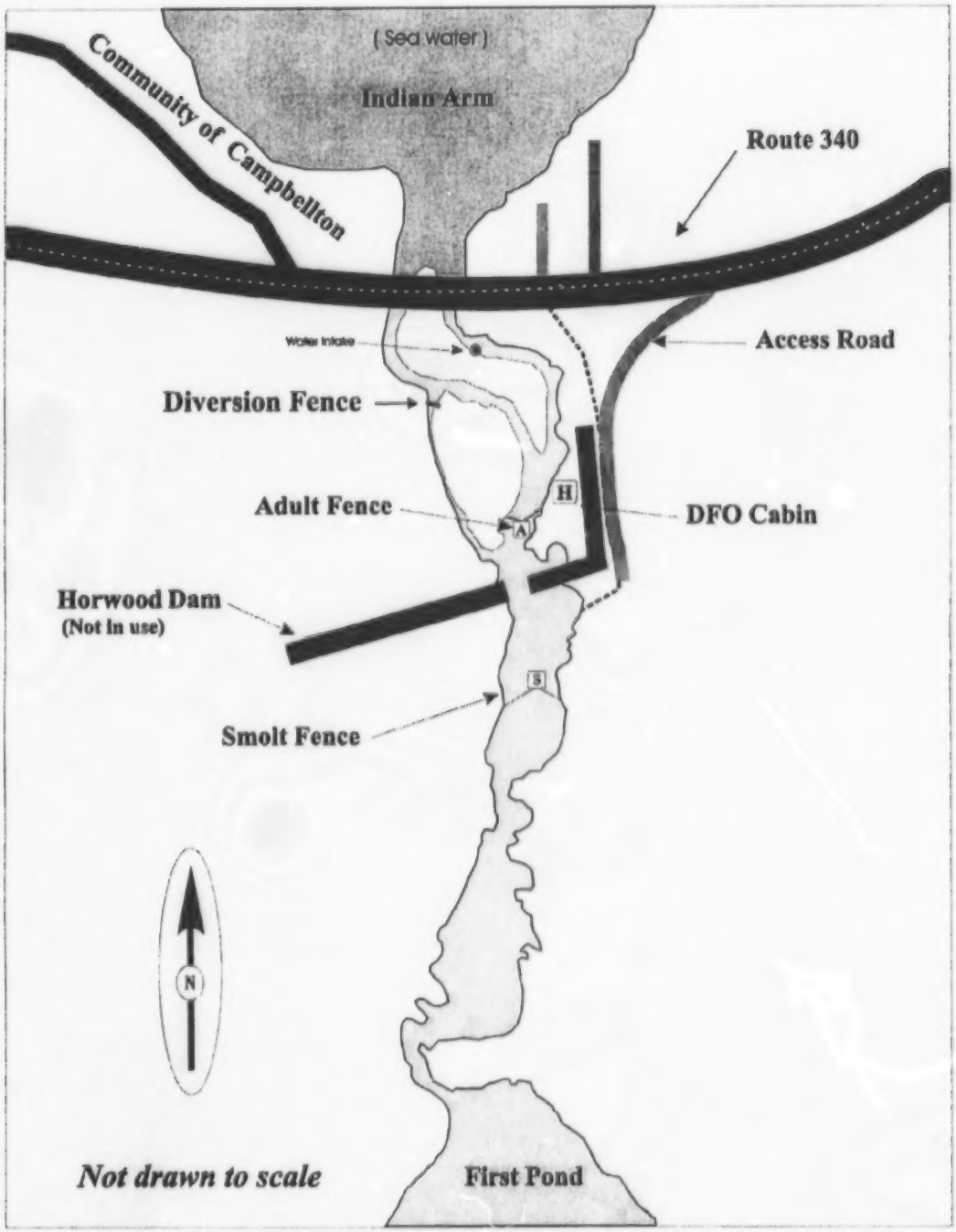

Figure 2. Campbellton River showing locations of the smolt and adult counting fences.

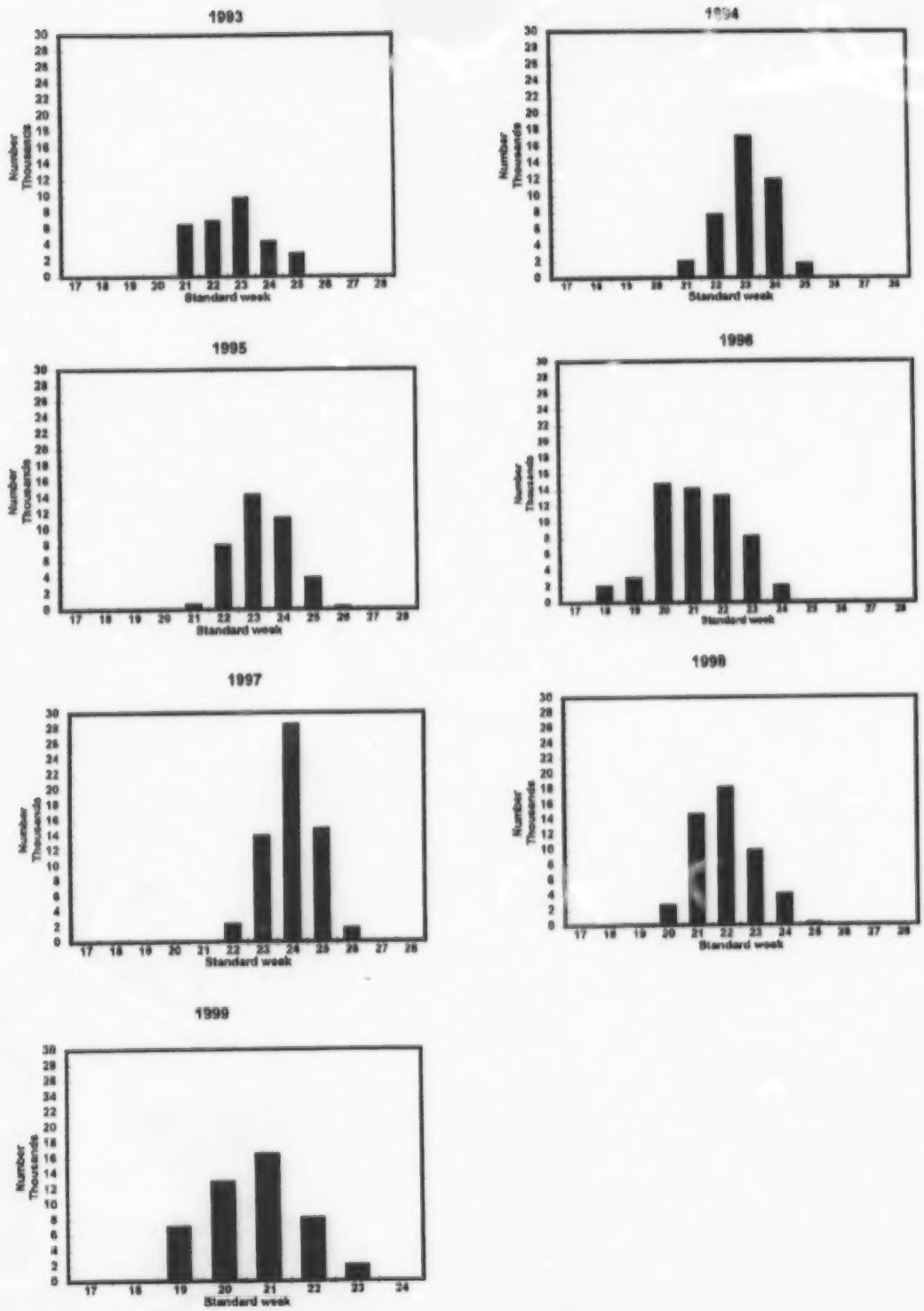

Figure 3. Downstream smolt migration at Campbellton River by standard week, 1993 - 99.

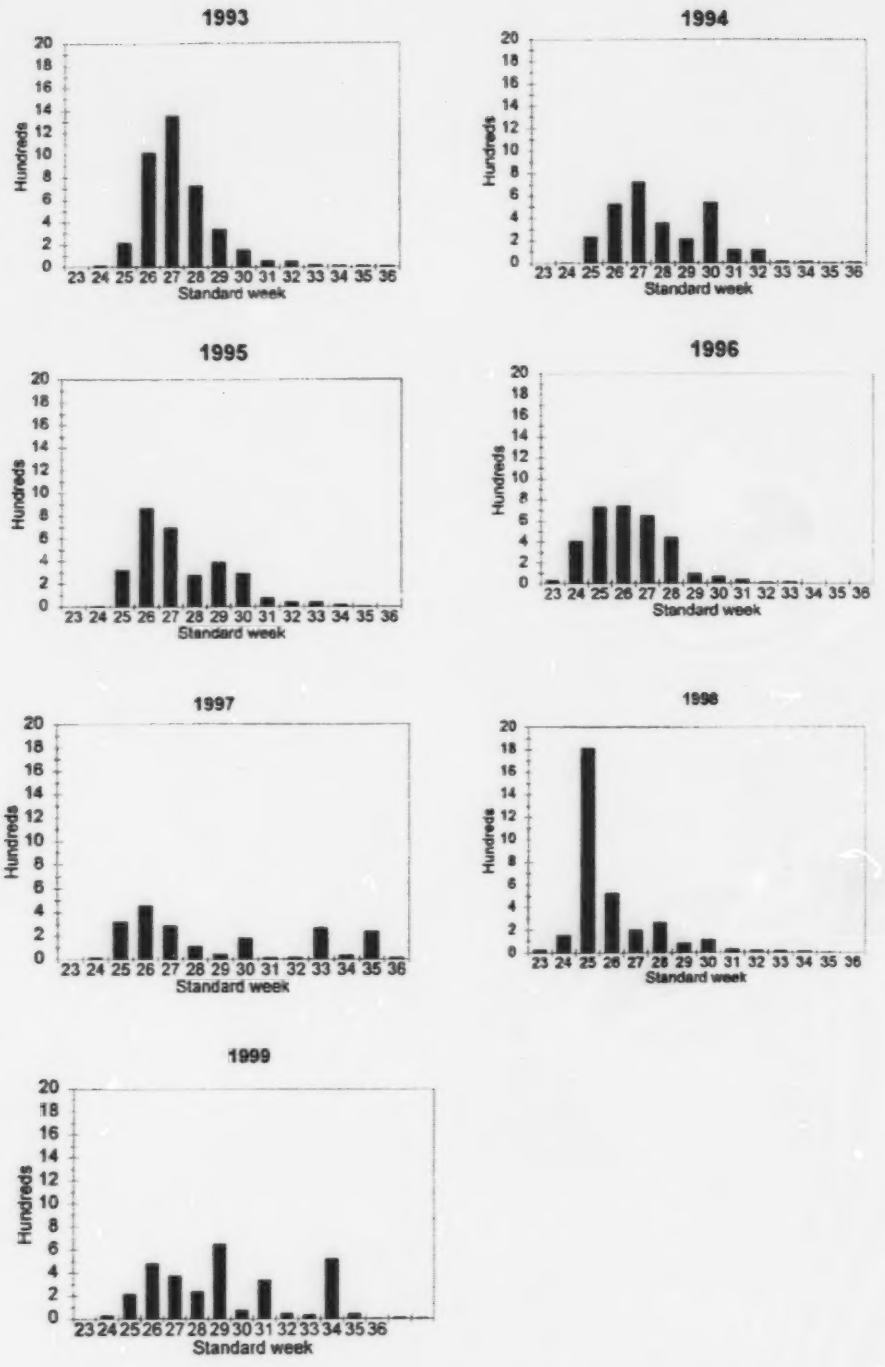

Figure 4. Adult small salmon upstream migrations by standard week enumerated at the counting fence, Campbellton River, 1993-99.

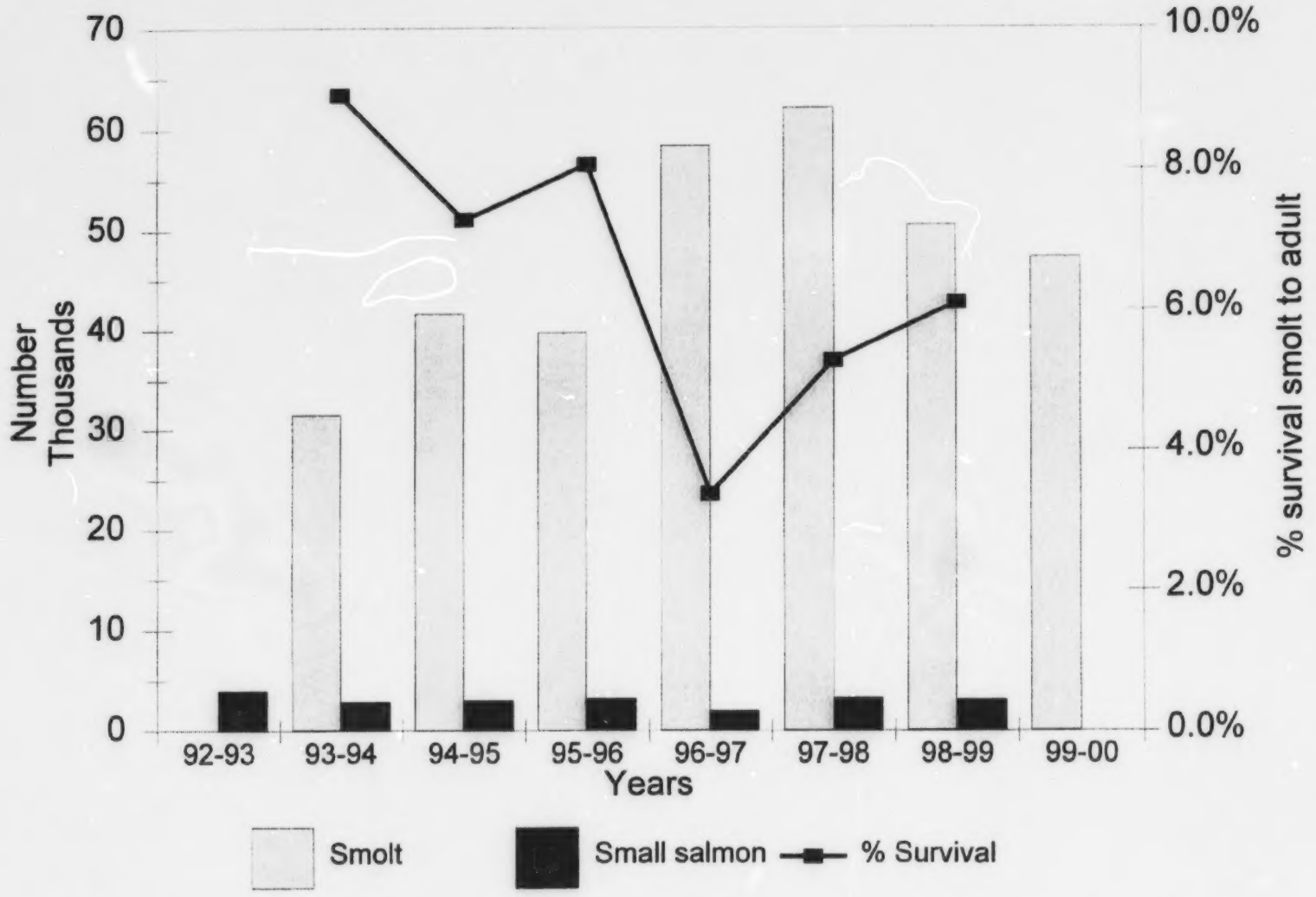

Figure 5. Smolt and small salmon Salmon migrations with percent survival (uncorrected for previous spawners) for Campbellton River, 1993 to 1999.

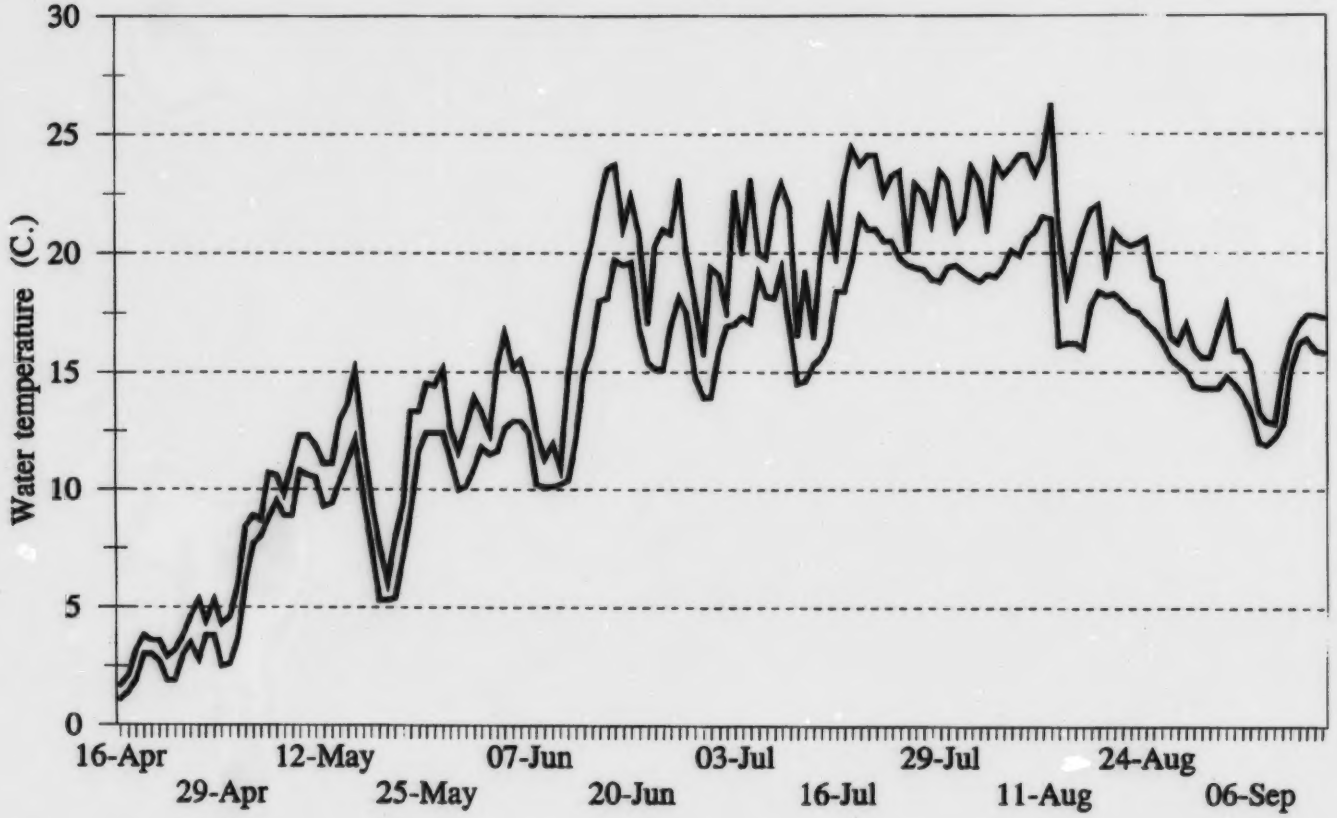

Figure 6. Minimum and maximum daily water temperatures for Campbellton River, 1999.

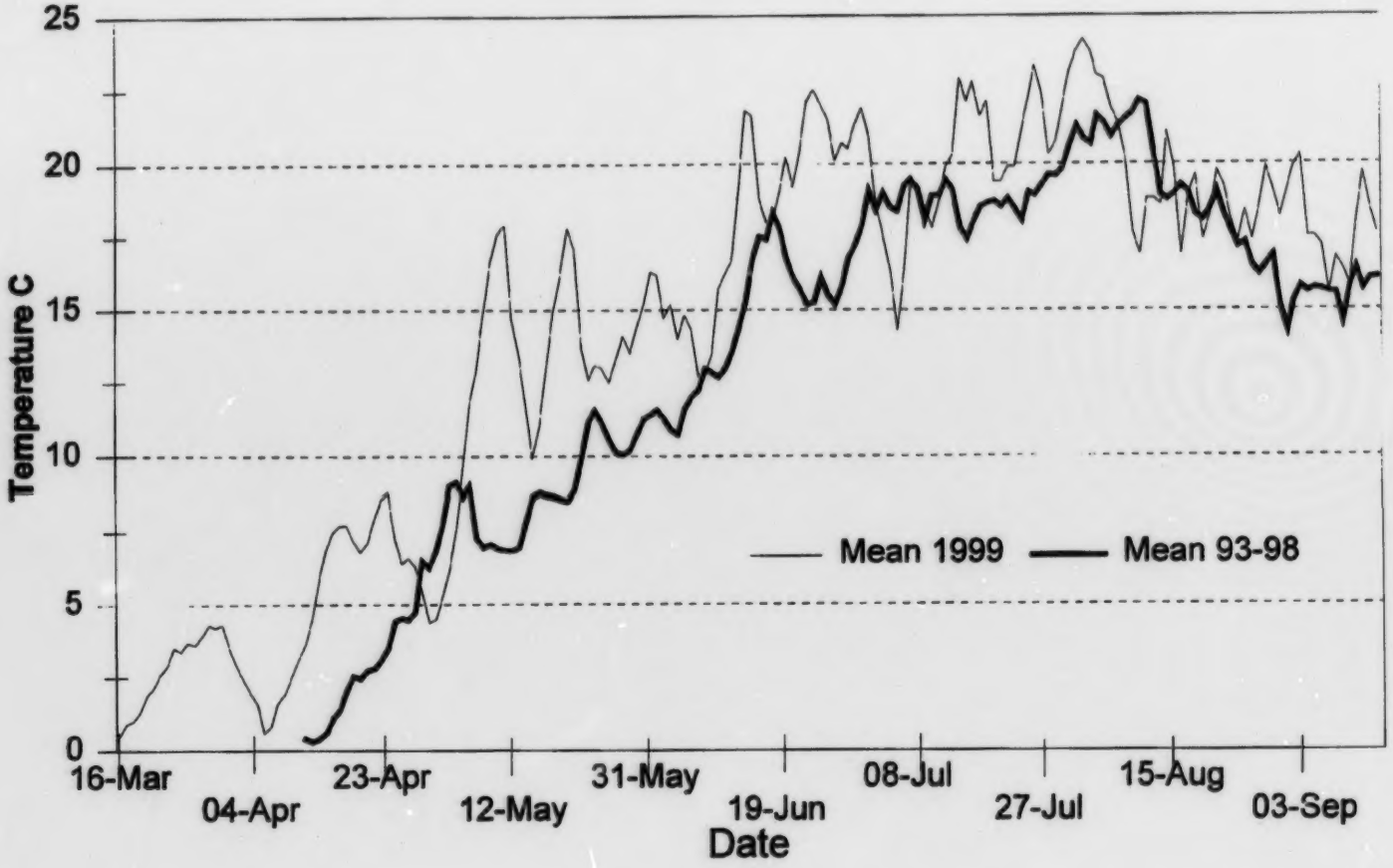

Figure 7. Campbellton River mean daily water temperatures from 1999 compared to the mean of 1993-98.

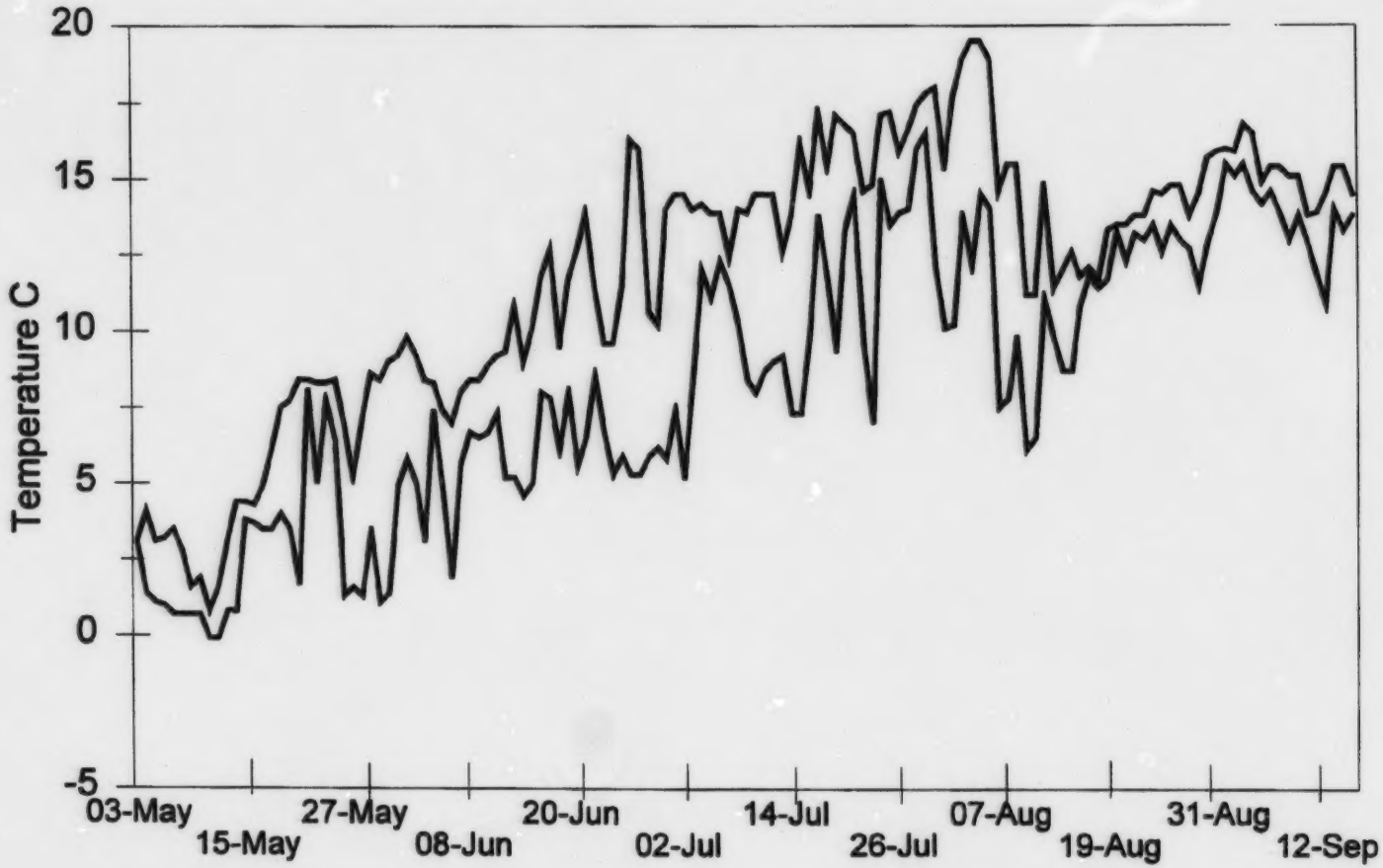

Figure 8. Minimum and maximum sea temperatures at 8 m from estuary of Campbellton River, 1999.

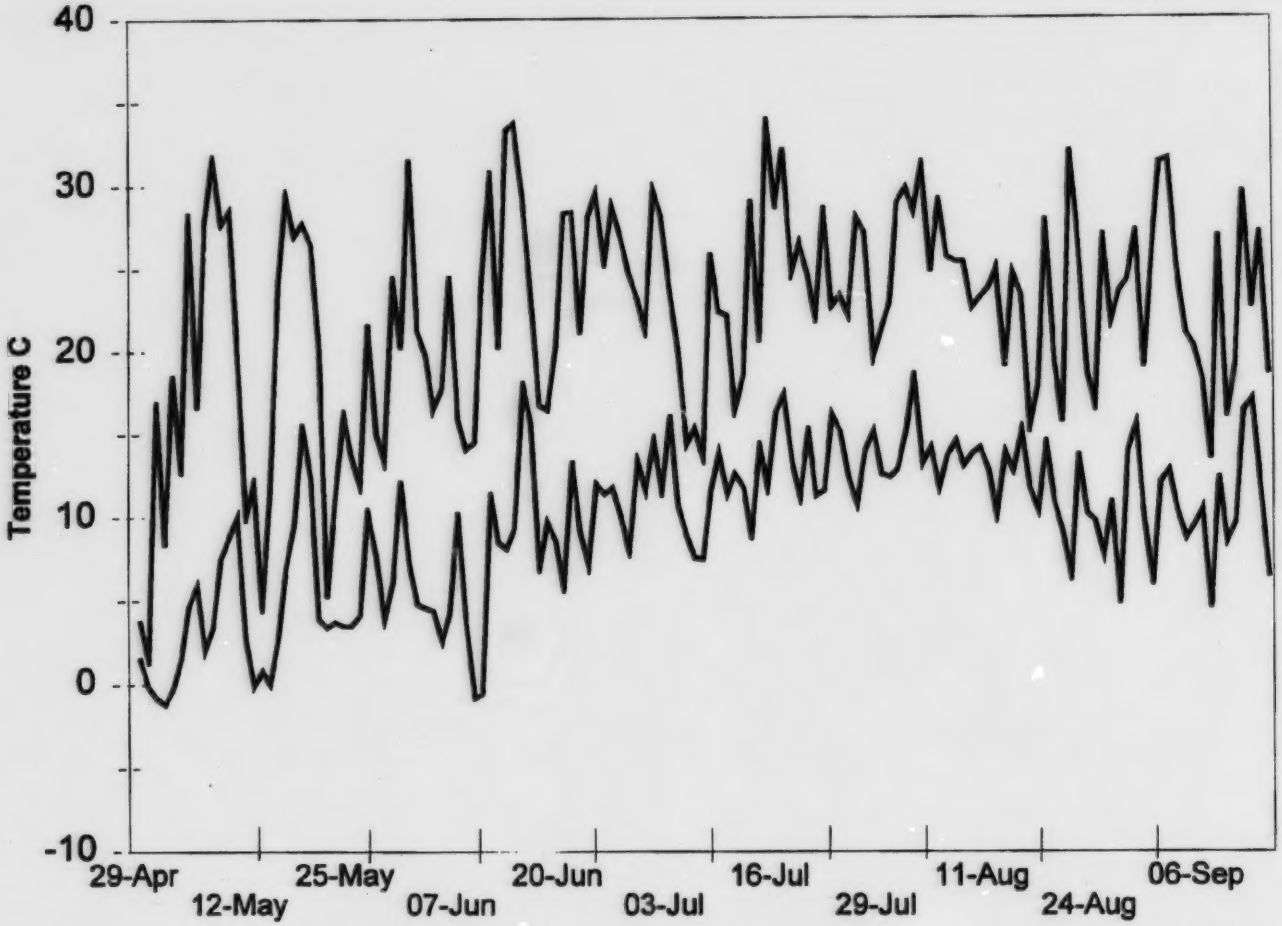

Figure 9. Maximiun and minimum air temperatures at the Campbellton River, 1999.

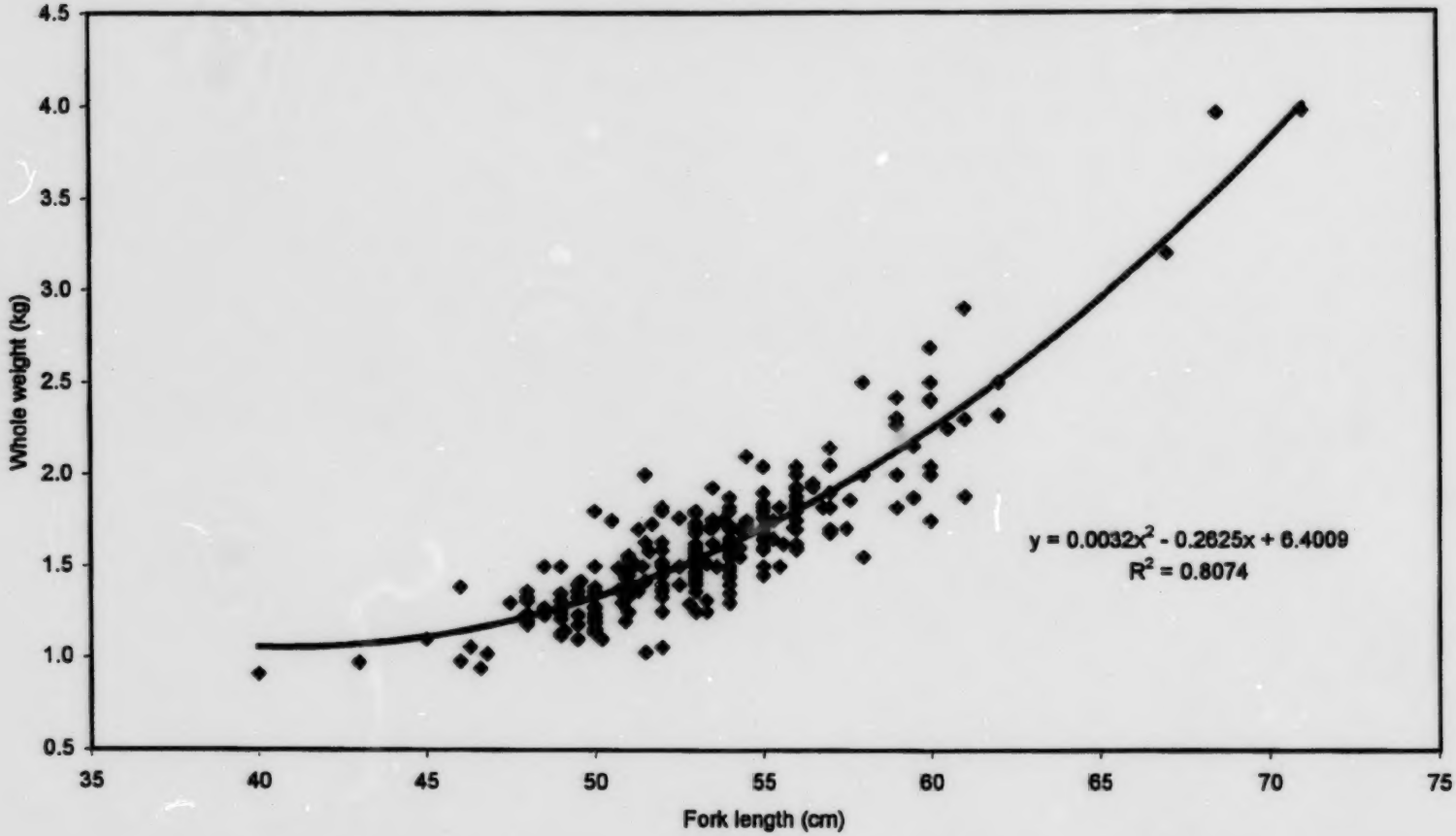

Figure 10. Regression of whole weight and fork length of adult salmon caught in the recreational fishery 1992-99.

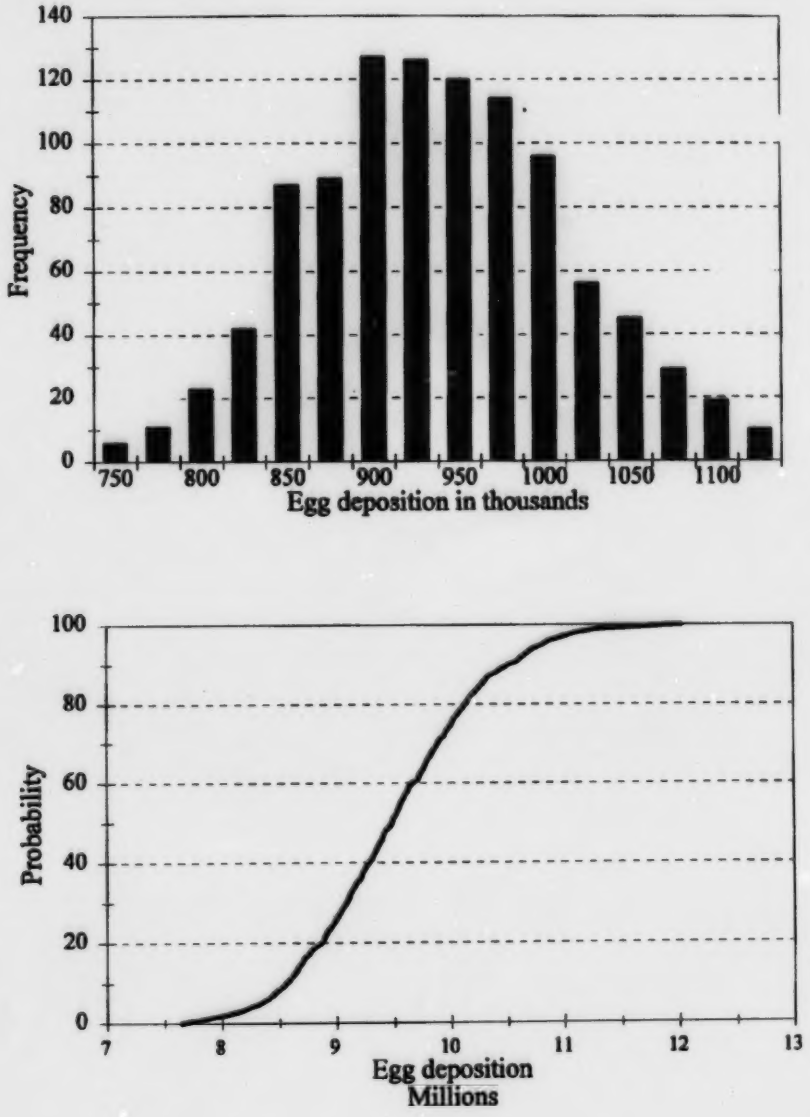

Fig. 11. Frequency distribution of the estimated egg deposition at Campbellton River, 1999 (upper panel) and the corresponding probability distribution (lower panel). The analysis with 1000 realizations assumed a 10% coefficient of variation around proportion female, relative fecundity, and mean weight of the small and large salmon components. Egg depositions are at the low-point of each interval.

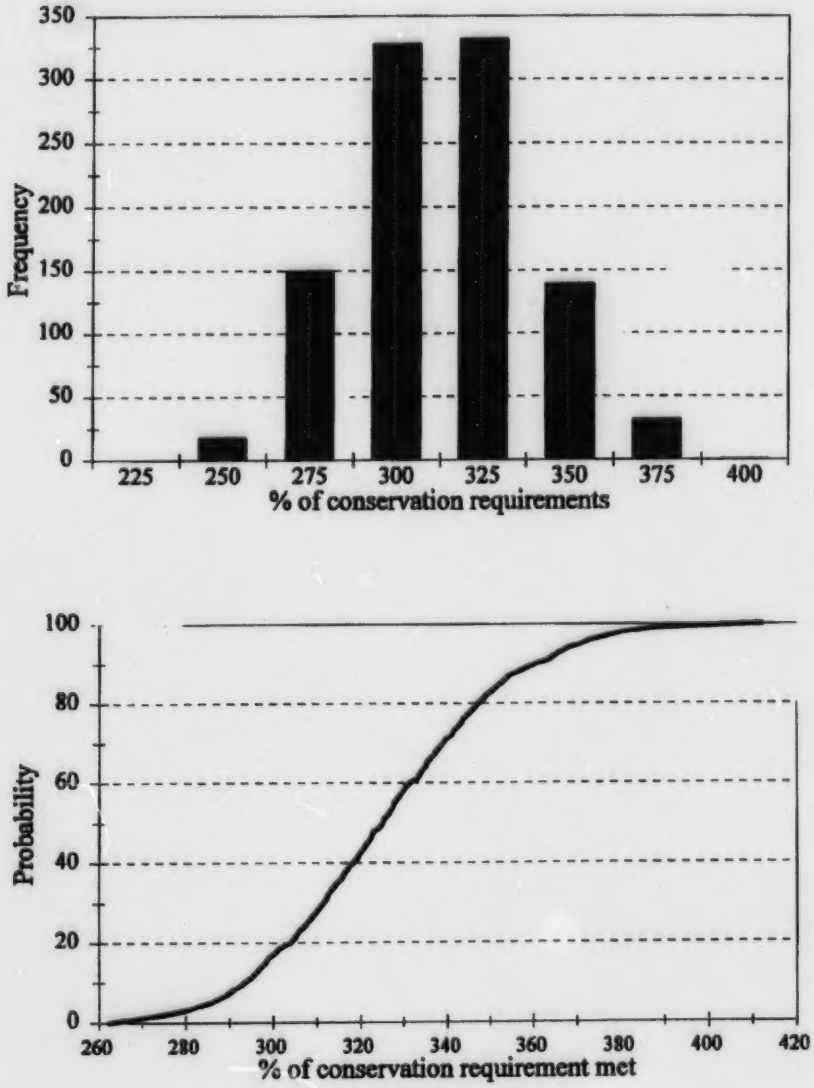

Fig. 12. Frequency distribution of the estimated percent of conservation requirement met at Campbellton River,1999 (upper panel) and the corresponding probability distribution (lower panel). The analysis with 1000 realizations assumed a 10% coefficient of variation around proportion female, relative fecundity, and mean weight of the small and large salmon components. Percent met are at the low end of each interval.

Table 1. The total rod days, total catch and catch per unit effort (CPUE) for both small and large Atlantic salmon retained in the recreational fishery for Insular Newfoundland ,Salmon Fishing Area 4 and the Campbellton River from 1953 to 1999.

	Rod days			Total catch (ret. + rel.)			CPUE		
Year	Insular NFLD	SFA 4	Campbellton River	Insular Newfoundland	SFA 4	Campbellton River	Insular Newfoundland	SFA 4	Campbellton River
1953	43,024	8,630	348	16,025	3,486	126	0.37	0.40	0.36
1954	28,806	7,346	567	8,705	1,600	102	0.31	0.22	0.17
1955	21,974	5,125	58	11,128	2,616	61	0.51	0.51	1.09
1956	53,092	10,672	341	16,702	4,350	119	0.31	0.41	0.35
1957	33,211	8,789	291	20,458	4,960	105	0.62	0.56	0.36
1958	34,444	5,888	582	20,844	5,001	447	0.61	0.85	0.76
1959	36,277	6,321	325	18,368	4,220	303	0.51	0.67	0.93
1960	35,750	7,051	313	17,336	3,950	266	0.48	0.56	0.85
1961	36,024	5,277	209	15,634	2,280	146	0.43	0.43	0.70
1962	49,035	8,842	397	24,808	4,879	147	0.51	0.55	0.37
1963	60,789	10,910	1,242	31,292	4,042	421	0.51	0.37	0.34
1964	71,541	15,808	1,066	39,276	7,917	498	0.55	0.51	0.47
1965	66,647	13,749	647	31,975	4,551	468	0.48	0.33	0.72
1966	66,414	15,249	881	30,605	6,627	689	0.46	0.43	0.78
1967	72,577	13,915	815	25,081	4,228	487	0.35	0.30	0.60
1968	75,575	15,318	1,577	31,303	6,139	743	0.41	0.40	0.47
1969	82,046	13,807	992	37,275	4,138	534	0.45	0.30	0.54
1970	84,912	15,759	660	32,592	4,896	437	0.38	0.31	0.66
1971	75,766	11,379	622	28,291	3,841	299	0.37	0.34	0.48
1972	69,219	10,778	452	25,804	3,468	210	0.37	0.32	0.46
1973	88,435	14,544	1,344	37,436	6,759	971	0.42	0.46	0.72
1974	108,189	22,038	1,958	27,898	5,455	505	0.26	0.25	0.26
1975	102,907	22,384	1,768	34,631	6,109	487	0.34	0.27	0.28
1976	115,847	24,787	2,042	35,514	6,871	834	0.31	0.28	0.41
1977	111,836	28,117	2,134	37,107	9,462	912	0.33	0.34	0.43
1978	96,659	24,131	1,314	30,182	8,276	429	0.31	0.36	0.33
1979	82,578	21,486	53	31,730	6,353	23	0.38	0.39	0.43
1980	104,332	25,172	2,293	37,771	9,921	1,112	0.36	0.39	0.48
1981	122,478	32,262	2,950	48,039	13,897	1,549	0.39	0.43	0.53
1982	129,360	32,929	1,674	43,119	10,231	473	0.33	0.31	0.28
1983	126,308	26,649	1,619	33,802	9,251	597	0.27	0.35	0.37
1984	121,979	29,633	2,657	39,842	9,915	992	0.33	0.33	0.37
1985	120,030	34,329	3,219	38,887	12,190	782	0.31	0.36	0.24
1986	123,528	31,650	1,791	38,294	9,293	422	0.31	0.29	0.24
1987	85,969	18,564	803	24,892	5,453	169	0.29	0.29	0.21
1988	120,497	27,413	1,837	40,441	9,854	836	0.34	0.36	0.35
1989	91,266	17,767	854	18,645	3,788	148	0.20	0.21	0.17
1990	105,736	23,533	883	30,470	5,661	106	0.29	0.24	0.15
1991	89,812	21,999	893	20,885	4,892	126	0.23	0.22	0.18
1992	95,931	19,485	916	30,173	6,810	341	0.31	0.35	0.37
1993	125,661	30,598	1,355	42,736	13,114	419	0.34	0.43	0.31
1994	141,508	43,242	1,484	39,381	12,158	345	0.28	0.28	0.23
1995	143,275	38,717	1,775	40,818	11,329	441	0.28	0.31	0.25
1996		44,385	1,964	57,825	17,586	587		0.40	0.30
1997 *				36,176	6,152	330			
1998 **				44,745	14,342	864			
1999 **				26,906	7,960	270			
Mean (53-99)	84,907	19,642	1,173	30,843	7,091	453			
Mean percent of Island		23.1%	1.4%		23.0%	1.5%			
Campbellton River to mean percent of SFA 4			5.97%			6.38%			

+ Note: recreation fishing closures occurred for SFA 4, therefore catch and effort are only a partial figures

** data obtained from the License Stub Retrun; 1999 figures are preliminary

Table 2. Atlantic salmon recreational statistics for Campbellton River, Notre Dame Bay, SFA 4, 1974-99.

River: Campbellton River **River code: 0708210**

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	Ret.	Rel.	Tot.	CPUE
1974	1956	505	.	505	0	.	0	505	.	505	0.26
1975	1768	424	.	424	63	.	63	487	.	487	0.28
1976	2042	834	.	834	0	.	0	834	.	834	0.41
1977	2134	895	.	895	17	.	17	912	.	912	0.43
1978	1314	426	.	426	3	.	3	429	.	429	0.33
1979	53	23	.	23	0	.	0	23	.	23	0.43
1980	2298	1112	.	1112	0	.	0	1112	.	1112	0.48
1981	2950	1547	.	1547	2	.	2	1549	.	1549	0.53
1982	1674	471	.	471	2	.	2	473	.	473	0.28
1983	1619	597	.	597	0	.	0	597	.	597	0.37
1984	2657	991	.	991	1	.	1	992	.	992	0.37
1985	3219	782	.	782	*	.	0	782	.	782	0.24
1986	1791	422	.	422	*	.	0	422	.	422	0.24
1987	803	169	.	169	*	.	0	169	.	169	0.21
1988	1837	636	.	636	*	.	0	636	.	636	0.35
1989	854	148	.	148	*	.	0	148	.	148	0.17
1990	693	106	.	106	*	.	0	106	.	106	0.15
1991	693	126	.	126	*	.	0	126	.	126	0.18
1992	916	311	30	341	*	0	0	311	30	341	0.37
1993	1355	316	103	419	*	0	0	316	103	419	0.31
1994	1484	340	4	344	*	1	1	340	5	345	0.23
1995	1775	393	47	440	*	1	1	393	48	441	0.25
1996	1964	463	93	556	*	31	31	463	124	587	0.30
1997**		254	67	321	*	9	9	254	76	330	
1998**		375	281	656	*	8	8	375	289	664	
1999		189	69	258	*	12	12	189	81	270	
84-89 $\bar{X}$	2071.6	595.8	.	595.8	.	.	.	596.0	.	596.0	0.29
95% CL	1123.4	403.8	.	403.8	.	.	.	404.2	.	404.2	0.10
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	1173.6	287.6	.	287.6	.	.	.	287.6	.	287.6	0.25
95% CL	730.6	289.8	.	289.8	.	.	.	289.8	.	289.8	0.11
N	5	5	0	5	0	0	0	5	0	5	5
92-96 $\bar{X}$	1498.8	364.6	55.4	420.0	.	6.6	6.6	364.6	62.0	426.6	0.28
95% CL	501.7	79.3	52.1	109.1	.	16.9	16.9	79.3	62.1	124.1	0.06
N	5	5	5	5	0	5	5	5	5	5	5

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1996 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.

** DATA DERIVED FROM THE RECREATIONAL LICENCE STUB RETURN (1999 FIGURES ARE PELIMINARY).

Table 3. Number of fishers, gear units and catches of Atlantic salmon in the commercial fishery for SFA 4 and Insular Newfoundland and means for 1984-90 compared to 1991.

Year	Salmon fishing Area 4						Insular Newfoundland					
	Number of commercial fisherman	Gear units (91.5 m)	Catch (metric tons)		Catch (numbers)		Number of commercial fisherman	Gear units (91.5 m)	Catch (metric tons)		Catch (numbers)	
			Small	Large	Small	Large			Small	Large	Small	Large
1984	692	3,124	73	50	38,857	10,976	3,065	11,008	241	240	130,131	54,283
1985	695	2,768	68	43	37,957	10,019	2,480	9,878	348	242	191,216	57,537
1986	696	2,782	119	81	59,902	17,047	2,480	9,916	392	282	200,267	60,699
1987	693	2,764	109	71	54,935	15,087	2,480	9,784	434	357	225,025	77,945
1988	682	2,728	68	35	36,016	8,179	2,380	9,520	249	191	134,562	43,581
1989	679	2,716	85	48	46,988	10,834	2,380	9,440	266	190	148,297	46,261
1990	669	2,674	62	31	32,648	6,940	2,320	9,270	171	180	92,554	39,497
Means (84-90)	715	2,794	83	51	43,900	11,297	2,509	9,831	300	240	160,293	54,258
1991	647	2,588	30	27	15,609	6,301	2,240	8,992	136	130	74,202	32,604
% drop in 1991 fishing, compared to 1984 to 1990 means	9.53%	7.36%	64.04%	47.35%	64.44%	44.23%	10.73%	8.53%	54.69%	45.90%	53.71%	39.91%

Note : In 1990 and 1991 a quota system was in placed and accounted for early closures for several SFA 's, during their fishing season, although set quota levels were not reached for SFA 4 and Insular Newfoundland for both years. Therefore slightly higher catches may have resulted in Insular Newfoundland.

Table 4. Daily count of downstream migrating fish at Campbellton River through the counting fence in 1999.

Date	Parr	Smolt	Kelt	Precocious post smolt	Ouananiche	Brook trout	Smelt	Eel
29-Apr	2						3	
30-Apr	9	2	7			1	12	
01-May	1		8				2	
02-May	3	1	36			3	33	
03-May	5	1	90			1	13	
04-May	14	9	117	1		2	8	
05-May	34	20	146	1	1	9	17	
06-May	44	76	128	5		17	3	
09-May	40	191	144	4	3	19	3	
08-May	34	515	96	5	1	30	2	
09-May	25	863	122	5	1	29	5	
10-May	18	1455	61	5	1	29	1	2
11-May	25	1941	107	3	2	36	4	
12-May	4	1406	82	3		22	2	
13-May	3	814	44	4	1	28	16	
14-May		334	5	3	1	4	21	
15-May	3	1006	17	3		7	11	
16-May	8	791	42	3		11	14	
17-May	13	2564	87	5		12	12	
18-May	6	2259	67	7	1	24	11	
19-May	7	3273	32	2		16	21	
20-May	9	2757	54			9	34	
21-May	5	2195	51	2		10	11	
22-May	2	1864	38	1		6	18	
23-May	6	3798	119	3		7	6	
24-May	2	1545	22	2		3		
25-May	4	1364	7	1		3	5	
26-May	2	3338	9	2		1	8	
27-May	1	2488	15	3		1	6	1
28-May	2	1642	11	1		2	12	
29-May	5	1068	15	1	1		3	
30-May	1	1412	15					
31-May	2	1018	8				6	
01-Jun	9	1637	15			1	6	
02-Jun	3	920	12			1	4	
03-Jun	1	546	9			2	1	
04-Jun		770	7	1			1	
05-Jun	3	198	2	1				
06-Jun	4	511	6				1	
07-Jun	3	328	3			1	2	
08-Jun		52	1				1	
09-Jun	5	229					2	
10-Jun	1	55						
Total	368	47256	1857	77	13	347	341	3

Table 5. Number and percent of smolt migrating downstream by standard week through the counting fence on the Campbellton River, 1993-99.

Dates		Standard week	1993		1994		1995		1996		1997		1998		1999		Mean	
			Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
April	23-29	17							44	0.08							6	0.01
May	30-06	18			1	0.00			2,146	3.68					109	0.23	324	0.69
	07-13	19			16	0.04	3	0.01	3,152	5.40			0	0.00	7,185	15.20	1,509	3.19
	14-20	20	125	0.40	224	0.54	15	0.04	14,833	25.41	20	0.03	2,772	5.50	12,984	27.48	4,698	9.93
	21-27	21	6,607	20.92	2,137	5.13	826	2.08	14,243	24.40	90	0.15	14,743	29.23	16,592	35.11	8,706	18.41
	28-03	22	7,071	22.39	7,842	18.82	8,228	20.72	13,358	22.89	2,491	4.01	18,322	36.32	8,243	17.44	10,716	22.66
June	04-10	23	9,915	31.40	17,297	41.52	14,409	36.28	8,264	14.16	14,017	22.59	9,957	19.74	2,143	4.53	10,114	21.38
	11-17	24	4,518	14.31	12,091	29.02	11,566	29.12	2,156	3.69	28,641	46.16	4,202	8.33			7,566	16.00
	18-24	25	3,011	9.54	1,876	4.50	4,020	10.12	121	0.21	14,908	24.03	445	0.88			3,236	6.84
	25-01	26	253	0.80	147	0.35	495	1.25	52	0.09	1,883	3.03					388	0.82
July	02-08	27	76	0.24	32	0.08	98	0.25									25	0.05
	09-15	28	0	0.00	0	0.00	55	0.14									8	0.02
Total			31,577		41,663		39,715		58,369		62,050		50,441		47,256		47,296	
Start date for fence			14-May		05-May		08-May		24-Apr		18-May		13-May		29-Apr			
End date for fence			10-Jul		12-Jul		15-Jul		30-Jun		01-Jul		20-Jun		10-Jun			

Table 6. The upsteam migration of Atlantic salmon adults through the counting fence on Campbellton River , 1999.

Date	Small	Large	Total
29-May			
30-May		1	1
31-May			
01-Jun			
02-Jun		1	1
03-Jun			
04-Jun			
05-Jun			
06-Jun	2	2	4
07-Jun	5	1	6
08-Jun	16		16
09-Jun	3		3
10-Jun	4	1	5
11-Jun	3	2	5
12-Jun	9		9
13-Jun	40	7	47
14-Jun	59	2	61
15-Jun	29	2	31
16-Jun	42	4	46
17-Jun	34		34
18-Jun	39	14	53
19-Jun	89	5	94
20-Jun	35		35
21-Jun	74	2	76
22-Jun	195	3	198
23-Jun	34		34
24-Jun	19		19
25-Jun	11		11
26-Jun	5	1	6
27-Jun	158	19	177
28-Jun	176	3	179
29-Jun	12		12
30-Jun	12	1	13
01-Jul	3		3
02-Jul	10	1	11
03-Jul	32	1	33
04-Jul	24	2	26
05-Jul	7		7

Table 6. The upsteam migration of Atlantic salmon adults through the counting fence on Campbellton River , 1999.

Date	Small	Large	Total
06-Jul	123	17	140
07-Jul	26	13	39
08-Jul	14	1	15
09-Jul	46	4	50
10-Jul	6	1	7
11-Jul	217	30	247
12-Jul	234	24	258
13-Jul	88	2	90
14-Jul	36	3	39
15-Jul	28	5	33
16-Jul	6	1	7
17-Jul		1	1
18-Jul	25	9	34
19-Jul	4	2	6
20-Jul	5		5
21-Jul	16	7	23
22-Jul	23		23
23-Jul	72	15	87
24-Jul	161	30	191
25-Jul	37	14	51
26-Jul	1		1
27-Jul	1		1
28-Jul	11	5	16
29-Jul	52	7	59
30-Jul	37	6	43
31-Jul	7	1	8
01-Aug			
02-Aug	1		1
03-Aug			
04-Aug			
05-Aug	1		1
06-Aug	1		1
07-Aug			
08-Aug	10	6	16
09-Aug	12	3	15
10-Aug	10		10
11-Aug			
12-Aug			

Table 6. The upsteam migration of Atlantic salmon adults through the counting fence on Campbellton River , 1999.

Date	Small	Large	Total
13-Aug			
14-Aug			
15-Aug			
16-Aug	399	157	556
17-Aug	70	36	106
18-Aug	18	4	22
19-Aug	33	6	39
20-Aug	12	2	14
21-Aug	12	2	14
22-Aug	6	1	7
23-Aug	1		1
24-Aug	5	1	6
25-Aug	5		5
26-Aug	2		2
27-Aug		1	1
28-Aug		1	1
29-Aug			
30-Aug			
31-Aug	2		2
01-Sep			
02-Sep	1		1
03-Sep	1		1
04-Sep	1		1
05-Sep			
06-Sep	3		3
07-Sep	2		2
08-Sep	1		1
09-Sep	1		1
10-Sep			
11-Sep	1		1
12-Sep	1		1
13-Sep	2		2
14-Sep	5		5
Total	3,076	493	3,569

Table 7. Number by standard week for upstream migration of adult Atlantic salmon through the counting facility on the Campbellton River, 1993-99.

Dates		Standard week	1993		1994		1995		1996		1997		1998		1999		1993 - 99				
			Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large	Total	Mean	Percent
May	28-03	22											0	0	0	2	0	2	2	0	0.01
June	04-10	23							33	9			27	7	30	4	90	20	110	16	0.46
	11-17	24	14	0	3	0	4	2	405	42	16	6	156	33	216	17	814	100	914	131	3.85
	18-24	25	217	6	234	28	322	28	729	57	317	16	1,813	59	485	24	4,117	218	4,335	619	18.25
	25-01	26	1,023	40	525	11	867	30	737	97	450	12	525	27	377	24	4,504	241	4,745	678	19.97
July	02-08	27	1,351	42	721	22	693	13	645	161	284	1	199	46	236	35	4,129	320	4,449	636	18.73
	09-15	28	727	25	353	15	279	4	439	120	113	19	266	146	655	69	2,832	398	3,230	461	13.60
	16-22	29	340	12	215	19	394	35	93	46	42	10	86	30	79	20	1,249	172	1,421	203	5.98
	23-29	30	155	7	538	47	297	45	69	18	180	51	112	37	335	71	1,686	276	1,962	280	8.26
August	30-05	31	59	1	118	18	78	23	37	6	18	9	36	3	46	7	392	67	459	66	1.93
	06-12	32	53	4	114	17	39	23	10	3	18	8	19	10	33	9	286	74	360	51	1.52
	13-19	33	25	3	16	7	40	11	11	1	258	109	18	1	520	203	888	335	1,223	175	5.15
	20-26	34	17	2	13	1	19	4			34	11	12	3	43	6	138	27	165	24	0.69
	27-02	35	12	0	3	3	3	0			230	64	5	0	3	2	256	69	325	46	1.37
September	03-09	36	8	3	4	3					15	5	1	0	11	0	39	11	50	7	0.21
	10-16	37													7	0	7	0	7	1	0.03
Total			4,001	145	2,857	191	3,035	218	3,208	560	1,975	321	3,275	402	3,076	493	21,427	2,330	23,757	3,394	
Percent			96.5	3.5	93.7	6.3	93.3	6.7	85.1	14.9	86.0	14.0	89.1	10.9	86.2	13.8	90.2	9.8			
Start date for fence			10-Jun		13-Jun		14-Jun		03-Jun		13-Jun		01-Jun		29-May						
End date for fence			07-Sep		12-Sep		29-Aug		20-Aug		08-Sep		08-Sep		14-Sep						

Table 8. Sea and freshwater survival rates for adult salmon from Campbellton River, 1994-99. Year is year of 1SW adult return.

Percent Survival	1999	1998	1997	1996	1995	1994	Mean % 94-99
Smolt to Small salmon uncorrected	6.10	5.28	3.38	8.08	7.28	9.05	6.53
Smolt to small salmon corrected	5.03	4.94	2.25	7.15	6.08	7.24	5.45
Percent difference (uncorrected to corrected)	17.54	6.44	33.43	11.51	16.48	20.00	17.57
Overwintering of previous spawners in freshwater	56.24	71.30	70.05	68.92	69.20	74.10	68.30
Previous spawners survival (<3 months) at sea	41.07	33.17	38.96	39.42	34.85	25.58	35.51

Due to the late installation of the smolt fence in 1998 the kelt migration was derived from data of previous years.

Table 9. River age and percent of sampled smolts from 1993-99 applied to the downstream smolt migrations for Campbellton River, 1993-99.

	River age											
	2		3		4		5		6			
Year	No.	%	No.	%	No.	%	No.	%	No.	%	Total enumerated at fence	Total sampled
93	0	0.00	15,631	49.50	15,315	48.50	632	2.00	0	0.00	31,577	199
94	171	0.41	25,931	62.24	12,620	30.29	2,766	6.64	171	0.41	41,663	241
95	191	0.48	24,774	62.38	13,805	34.76	945	2.38	0	0.00	39,715	210
96	671	1.15	34,975	59.92	20,050	34.35	2,673	4.58	0	0.00	58,369	262
97	230	0.37	35,685	57.51	24,547	39.56	1,365	2.20	230	0.37	62,050	273
98	212	0.42	22,658	44.92	25,009	49.58	2,562	5.08	0	0.00	50,441	236
99	0	0.00	21,766	46.06	24,559	51.97	931	1.97	0	0.00	47,256	254
Mean	199	0.42	25,879	54.71	19,474	41.17	1,693	3.58	57	0.12	47,303	239

Table 10. Mean fork length, whole weight and river age of salmon smolts sampled from the smolt fence at Campbellton River, 1993-99.

Year	Sex	Fork length (mm)					Whole weight (grams)					Mean river age (yrs)				
		Mean	Number	STD	Min.	Max.	Mean	Number	STD	Min.	Max.	Mean	Number	STD	Min.	Max.
93	Male	186.4	58	20.5	145.0	275.0	60.2	58	22.2	24.6	175.6	3.53	58	0.54	3	5
	Female	186.2	141	19.9	127.0	252.0	60.7	141	21.1	22	148.6	3.52	141	0.54	3	5
94	Male	172.1	49	14.2	140.0	200.0	48.0	49	12.5	24.7	88.2	3.40	48	0.64	3	5
	Female	173.0	196	18.6	135.0	267.0	49.4	196	18.0	21.8	174.0	3.46	193	0.64	2	6
95	Male	168.9	61	14.3	135.0	200.0	44.0	61	12.31	22.4	84.5	3.49	61	0.60	3	5
	Female	169.1	150	16.0	132.0	221.0	44.7	150	13.46	22.9	86.1	3.35	149	0.52	2	5
96	Male	174.0	80	16.5	147.0	227.0	47.1	80	15.34	24.8	116.9	3.49	79	0.60	3	5
	Female	176.0	183	20.6	130.0	256.0	50.0	183	19.74	19.1	155.6	3.39	183	0.60	2	5
97	Male	167.1	90	22.2	133.0	268.0	43.1	90	22.5	18.9	188.2	3.60	90	0.67	3	6
	Female	166.5	184	20.8	133.0	278.0	42.9	184	19.99	18.3	206.9	3.37	183	0.50	2	4
98	Male	171.7	57	13.7	144.0	209.0	46.3	57	12.27	26.5	92.3	3.58	57	0.60	3	5
	Female	170.3	176	22.2	122.0	250.0	48.5	176	21.59	17.5	152.5	3.57	176	0.57	2	5
99	Male	175.6	65	20.6	141.0	241.0	52.4	65	20.29	27.2	133.8	3.62	65	0.55	3	5
	Female	171.8	189	16.3	129.0	223.0	47.0	189	13.89	20.6	104.4	3.54	189	0.53	3	5
All	Male	173.3	460	18.9	133.0	275.0	48.3	460	18.5	18.9	188.2	3.54	458	0.6	3	6
	Female	173.0	1219	20.1	122.0	278.0	48.8	1219	19.1	17.5	206.9	3.46	1214	0.6	2	6
	All	173.0	1679	19.8	122.0	278.0	48.6	1679	18.9	17.5	206.9	3.48	1672	0.6	2	6

Table 11. Biological characteristics of small salmon sampled in the recreational fishery at Campbellton River, 1992-99.

		Fork length (cm)					Whole weight (kgs)					River age (years)				
Year	Sex	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max	Mean	Number	STD	Min	Max
92	Male	55.88	4	3.97	52.0	60.0	1.83	3	0.58	1.50	2.50	3.50	4	1.00	3	5
	Female	53.00	13	4.93	43.5	62.5	1.75	2		1.75	1.75	3.38	13	0.51	3	4
	All	54.18	17	4.71	43.5	62.5	1.81	4	0.47	1.50	2.50	3.41	17	0.62	3	5
93	Male	53.03	23	3.50	48.0	62.0	1.55	23	0.29	1.16	2.50	3.09	23	0.29	3	4
	Female	52.42	64	2.49	46.0	57.5	1.47	60	0.21	0.96	1.92	3.03	61	0.36	2	4
	All	52.58	87	2.78	46.0	62.0	1.50	83	0.23	0.96	2.50	3.05	84	0.34	2	4
94	Male	55.76	10	3.13	52.5	60.5	1.79	10	0.36	1.40	2.31	3.17	12	0.39	3	4
	Female	52.71	31	3.13	46.3	59.5	1.59	28	0.28	0.94	2.19	3.25	32	0.51	3	5
	All	53.45	41	3.36	46.3	60.5	1.62	38	0.31	0.94	2.31	3.23	44	0.48	3	5
95	Male	53.89	10	3.56	49.0	61.0	1.72	9	0.38	1.13	2.30	3.30	10	0.48	3	4
	Female	52.47	45	3.44	43.0	62.0	1.55	38	0.32	0.97	2.42	3.30	44	0.51	2	4
	All	52.69	55	3.46	43.0	62.0	1.58	47	0.33	0.97	2.42	3.30	54	0.50	2	4
96	Male	50.83	3	1.87	48.5	52.0	1.44	3	0.10	1.33	1.50	3.50	2	0.71	3	4
	Female	51.50	6	4.23	45.0	56.0	1.58	5	0.41	1.10	2.10	3.33	6	0.52	3	4
	All	51.21	9	3.50	45.0	56.0	1.53	8	0.33	1.10	2.10	3.38	8	0.52	3	4
97	Male	53.05	4	3.91	49.5	58.0	1.66	4	0.35	1.23	2.00	3.50	4	0.58	3	4
	Female	52.08	18	3.96	40.0	56.5	1.43	17	0.28	0.91	1.93	3.33	18	0.49	3	4
	All	52.26	22	3.86	40.0	58.0	1.48	21	0.30	0.91	2.00	3.36	22	0.49	3	4
98	Male	54.50	2	2.12	53.0	56.0	1.69	2	0.15	1.59	1.80	3.50	2	0.71	3	4
	Female	53.30	21	2.66	49.5	60.0	1.53	20	0.23	1.13	2.04	3.44	18	0.51	3	4
	All	53.40	23	2.60	49.5	60.0	1.54	22	0.30	1.13	2.04	3.45	20	0.51	3	4
99	Male	55.16	12	3.66	50.8	61.0	1.77	12	0.42	1.36	2.90	3.90	10	0.74	3	5
	Female	54.47	29	3.25	48.0	60.5	1.69	32	0.37	1.10	2.50	3.61	31	0.50	3	4
	All	54.67	41	3.40	48.0	61.0	1.71	44	0.38	1.10	2.90	3.66	41.0	0.67	3	5
92-99	Male	54.01	68	3.58	48.0	62.0	1.67	66	0.35	1.13	2.90	3.33	67	0.56	3	5
	Female	52.83	227	3.27	40.0	62.5	1.54	201	0.29	0.91	2.50	3.30	224	0.66	2	7
	All	53.11	295	3.38	40.0	62.5	1.57	267	0.31	0.91	2.90	3.31	291	0.66	2	7

Table 12. River age and percent of salmon sampled in the recreational fishery or the adult counting fence at Campbellton River, 1992-99.

		River age												
		2		3		4		5		6		7		
Year	Size	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Total
1992	small	1	4.55	15	68.18	5	22.73	1	4.55	0	0.00	0	0.00	22
1993	small	4	4.60	75	86.21	8	9.20	0	0.00	0	0.00	0	0.00	87
1994	small	0	0.00	35	79.55	8	18.18	1	2.27	0	0.00	0	0.00	44
1995	small	1	1.85	36	66.67	17	31.48	0	0.00	0	0.00	0	0.00	54
1996	small	0	0.00	5	55.56	4	44.44	0	0.00	0	0.00	0	0.00	9
1997	small	0	0.00	14	63.64	8	36.36	0	0.00	0	0.00	0	0.00	22
1998	large	0	0.00	17	62.96	7	25.93	3	11.11	0	0.00	0	0.00	27
	small	0	0.00	19	46.34	17	41.46	4	9.76	0	0.00	1	2.44	41
1999	large	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2
	small	0	0.00	17	39.53	24	55.81	2	4.65	0	0.00	0	0.00	43
Total		6	1.71	233	66.38	99	28.21	12	3.42	0	0.00	1	0.28	351

Table 13. Percent male and female for adult salmon sampled in the recreational fishery and smolt sampled form the trap at Campbellton River, 1992-99.

	Male				Female			
	Adult		Smolt		Adult		Smolt	
Year	Number	Percent	Number	Percent	Number	Percent	Number	Percent
92	4	23.53			13	76.47		
93	23	26.44	58	29.15	64	73.56	141	70.85
94	12	27.27	48	19.92	32	72.73	193	80.08
95	10	18.18	61	29.05	45	81.82	149	70.95
96	3	33.33	79	30.15	6	66.67	183	69.85
97	4	18.18	90	32.97	18	81.82	183	67.03
98	2	8.33	57	24.46	22	91.67	176	75.54
99	12	26.09	65	25.59	34	73.91	189	74.41
Mean	70	23.18	458	27.39	232	76.82	1214	72.61

Table 14. Campbellton River adult salmon returns, spawning escapment and egg deposition, 1993-99.

SPAWNING ESCAPEMENT $SE = (FR - RCT) - (HRM)$

SE= Spawning escapment
FR= Fish released by counting fence
RCT= Recreational catch (retained)
RCL= Recreational catch (released)
HRM= Recreational mortality (RCL *0.1)

		1993	1994	1995	1996	1997	1998	1999	Average
FR	Small	4001	2857	3035	3208	1975	3275	3078	3059
	Large	145	191	218	560	321	402	493	305
RCL	Small	103	4	47	93	67	281	89	99
	Large	0	1	1	31	9	8	12	8
HRM	Small	10	0	5	9	7	28	7	10
	Large	0	0	0	3	1	1	1	1
RCT	Small	316	340	393	463	254	375	189	357
	Large	0	0	0	0	0	0	0	0
SE	Small	3675	2517	2637	2736	1714	2872	2880	2692
	Large	145	191	218	557	320	401	492	305

EGG DEPOSITION $ED = SE * PF * RF * MW$

ED= Egg deposition
SE= Spawning escapment
PF= Proportion females
RF= Relative fecundity (eggs/kg)
MW= Mean weight of females

	Year	1993	1994	1995	1996	1997	1998	1999	AVERAGE
SE	Small	3675	2517	2637	2736	1714	2872	2880	2719
	Large	145	191	218	557	320	401	492	332
PF	Small	0.736	0.727	0.818	0.667	0.818	0.774	0.739	0.754
	Large	0.769	0.769	0.769	0.769	0.769	0.769	0.769	0.769
RF	Small	2100	2100	2100	2100	2100	2100	2100	2100
	Large	2100	2100	2100	2100	2100	2100	2100	2100
MW	Small	1.47	1.58	1.55	1.58	1.43	1.51	1.57	1.52
	Large	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13
ED	Small	8344498	5998139	7023765	6051671	4211089	7048659	7017315	6527592
	Large	732922	964930	1101405	2814927	1617989	2027920	2485870	1677995
Total		9077421	6963069	8125171	8866598	5829088	9076580	9503185	8205587
Conservation requirements		2916000	2916000	2916000	2916000	2916000	2916000	2916000	2916000
% requirements		311	239	279	304	200	311	326	281

The PF and MW for large salmon are default values calculated from several rivers in Notre Dame Bay (O'Connell et al.1996).

* Due to the low recreational sampling base (24 fish) in 1998 the mean MW and PF derived from 1992-98 were used.

Table 15a. Summary of assessment of Campbellton River salmon stock based on upstream migrating adults. Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality at 10%				Spawning escapement		Mean WW female		Percent female		Fecundity (eggs/kg)		Egg deposition		Total	Percent of conservation requirement
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		
93	4001	145	316	10	0	0	3675	145	1.47	3.13	73.56	76.90	2100	2100	8,345,180	732,922	9,078,102	311
94	2857	191	340	0	0	0	2517	191	1.56	3.13	72.73	76.90	2100	2100	5,997,092	965,436	6,962,527	239
95	3035	218	393	5	0	0	2637	218	1.55	3.13	81.82	76.90	2100	2100	7,022,967	1,101,911	8,124,877	279
96	3208	560	463	9	0	3	2736	557	1.58	3.13	66.67	76.90	2100	2100	6,052,335	2,815,433	8,867,767	304
97	1975	321	254	7	0	1	1714	320	1.43	3.13	81.82	76.90	2100	2100	4,211,592	1,617,484	5,828,875	200
98	3275	402	375	28	0	1	2872	401	1.51	3.13	77.4	76.9	2100	2100	7,048,659	2,026,909	9,075,569	311
99	3076	493	189	7	0	1	2880	492	1.57	3.13	73.91	76.9	2100	2100	7,018,264	2,485,870	9,504,135	326

Table 15b. Summary of assessment of Campbellton River salmon stock based on downstream migrating kelts from the next year. Based on a conservation requirement of 2,916,000 eggs.

Year	Fence count		Angling catch and mortality at 10%				Spawning escapement		Mean FL		Percent female		Fecundity (eggs/kg)		Egg deposition		Total	Percent of conservation requirement
	Small	Large	Small	Mortality	Large	Mortality	Small	Large	Small	Large	Small	Large	Small	Large	Small	Large		
93	4001	145	316	10	0	0	3675	145	52.03	65.17	73.56	76.90	59.97	59.97	8,435,036	435,789	8,870,825	304
94	2857	191	340	0	0	0	2517	191	53.25	65.00	72.73	76.90	59.97	59.97	5,845,888	572,542	6,418,429	220
95	3035	218	393	5	0	0	2637	218	52.33	68.37	81.82	76.90	59.97	59.97	6,771,025	687,357	7,458,382	256
96	3208	560	463	9	0	3	2736	557	52.04	69.03	66.67	76.90	59.97	59.97	5,692,695	1,773,183	7,465,877	256
97	1975	321	254	7	0	1	1714	320	52.35	68.07	81.82	76.90	59.97	59.97	4,402,720	1,004,537	5,407,257	185
98	3275	402	375	25	0	1	2875	401	51.89	69.12	77.4	76.90	59.97	59.97	6,924,629	1,278,228	8,202,858	281
99	3076	493	189	7	0	1	2880	492			73.91	76.90	59.97	59.97				

Note: Mean fork length of kelts are applied to the previous year data to represent upstream migrating fish.

APPENDIX 1

Sea survival rates for Campbellton River salmon, 1994

Sea survival rates for 93 smolt class:

Smolt count - 93		= 31,577
Adult count (small only) - 94		= 2,857
Sea survival rate – 93 (uncorrected)	*(2,857 / 31,577)*	= 9.05%

Previous spawners:

Kelts (downstream) - 94		= 2,838
Tagged kelts (downstream) – 94 (first year of kelt tagging)		= 942
Ratio untagged : tagged (total)	*(2,838 / 942)*	= 3.01
Overwintering survival- 93 to 94 with the recreational catch removed	*(2,838 / (4,146-316))*	=74.10%

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '94	Percent previous spawners
Small	190	572	2,857	20.0
Large	51	154	191	80.6
Total	241	726	3,048	23.8

Sea survival rates with correction for previous spawners:

Smolt count - 93		= 31,577
Upstream grilse - 94	*(2,857-572)*	= 2,285
Previous spawners survival 3 mo	*(726 / 2,838)*	= 25.58%
Corrected smolt sea survival - 93	*(2,285 / 31,577)*	= 7.24%

APPENDIX 2

Sea survival rates for Campbellton River salmon, 1995

Sea survival rates for 94 smolt class:

Smolt count - 94		= 41,663
Adult count (small only) - 95		= 3,035
Sea survival rate – 94 (uncorrected)	*(3,035 / 41,663)*	= 7.28 %

Previous spawners:

Kelts (downstream) - 95		= 1,874
Tagged kelts (downstream) – 95 (448 tagged in '95 & 152 from '94)		= 600
Ratio untagged : tagged (total)	*(1,874 / 600)*	= 3.12
Overwintering survival- 94 to 95 with the recreational catch removed	*(1,874 / (3,048-340))*	= 69.20 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '95	Percent previous spawners
Small	160	500	3,035	16.5
Large	49	153	218	70.2
Total	209	653	3,253	20.1

Sea survival rates with correction for previous spawners:

Smolt count - 94		= 41,663
Upstream grilse - 95	*(3,035-500)*	= 2,535
Previous spawners survival 3 mo	*(653 / 1,874)*	= 34.85 %
Corrected smolt sea survival - 94	*(2,535 / 41,663)*	= 6.08 %

APPENDIX 3

Sea survival rates for Campbellton River salmon, 1996

Sea survival rates for 95 smolt class:

Smolt count - 95		= 39,715
Adult count (small only) - 96		= 3,208
Sea survival rate – 95 (uncorrected)	*(3,208 / 39,715)*	= 8.08 %

Previous spawners:

Kelts (downstream) - 96		= 1,971
Tagged kelts (downstream) – 96 (484 tagged in '96 & 100 from '94-95)		= 584
Ratio untagged : tagged (total)	*(1,971 / 584)*	= 3.38
Overwintering survival- 95 to 96 with the recreational catch removed	*(1,971 / (3,253-393))*	= 68.92 %

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '96	Percent previous spawners
Small	109	368	3,208	11.5
Large	121	409	560	73.0
Total	230	777	3,768	20.6

Sea survival rates with correction for previous spawners:

Smolt count - 95		= 39,715
Upstream grilse - 96	*(3,208-368)*	= 2,840
Previous spawners survival 3 mo	*(777 / 1,971)*	= 39.42%
Corrected smolt sea survival - 95	*(2,840 / 39,715)*	= 7.15%

APPENDIX 4

Sea survival rates for Campbellton River salmon, 1997

Sea survival rates for 96 smolt class:

Smolt count - 96		= 58,369
Adult count (small only) - 97		= 1,975
Sea survival rate – 96 (uncorrected)	*(1,975 / 58,369)*	= 3.38%

Previous spawners:

Kelts (downstream) - 97		= 2,315
Tagged kelts (downstream) – 97 (347 tagged in '97 & 112 from '94-96)		= 459
Ratio untagged : tagged (total)	*(2,315 / 459)*	= 5.04
Overwintering survival- 96/97 with the recreational catch removed	*(2,315 / (3,768-463))*	= 70.05%

The following table is a summary of the estimated numbers of previous spawners in small and large categories:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '97	Percent previous spawners
Small	131	660	1,975	33.4
Large	48	242	321	75.4
Total	179	902	2,296	39.3

Sea survival rates with correction for previous spawners:

Smolt count - 96		= 58,369
Upstream grilse - 97	*(1,975-660)*	= 1,135
Previous spawners survival 3 mo	*(902 / 2,315)*	= 38.96%
Corrected sea smolt survival - 96	*(1,315 / 58,369)*	= 2.25%

APPENDIX 5
Sea survival rates for Campbellton River salmon, 1998

Sea survival rates for 97 smolt class:

Smolt count - 97		= 62,050
Adult count (small only) - 98		= 3,275
Sea survival rate – 97 (uncorrected)	*(3,275 / 62,050)*	= 5.28 %

Previous spawners:

Kelts (downstream) - 98		= 351 (1,456)
Tagged kelts (downstream) – 98		= 128 (274)
(109 tagged in '98 & 19 + *x* from '94-97)		
Ratio untagged : tagged (total)	*(351 / 128)*	= 2.74 (5.31)
	or *(1456/274)*	
Over-wintering survival- 97/98		= 17.19% (71.30)
with the recreational catch removed	*(351 / (2296-254)*	
	or (1,456/ (2296-254)	

The following table is a summary of the estimated numbers of previous spawners in small and large categories using previous spawners actual counts and derived figures:

	UPSTREAM MIGRATIONS			
	Tagged	Est. previous spawners	Total '98	Percent previous spawners
Small	40	112 (212)	3,275	3.4 (6.47)
Large	51	143 (271)	402	35.6 (67.4)
Total	91	255 (483)	3,677	6.9 (13.1)

Sea survival rates with correction for previous spawners:

Smolt count - 97		= 62,050
Upstream grilse - 98	*(3,275-112)*	= 3,163 (3,063)
Previous spawners survival 3 mo	*(255 / 351)*	= 72.65% (33.17)
Corrected sea smolt survival - 97	*(3,163 / 62,050)*	= 5.10% (4.94)

Note: Due to the late installation of the smolt fence, downstream kelt counts appear to be incomplete, therefore the kelt migration and those with tags attached were calculated by using ratios of kelt migrations and tagging from previous years. These derived figures used in the above calculations are indicated with brackets.

APPENDIX 6

Sea survival rates for Campbellton River salmon, 1999

Sea survival rates for 98 smolt class:

Smolt count - 98		= 50,441
Adult count (small only) - 99		= 3,076
Sea survival rate – 98 (uncorrected)	*(3,076 / 50,441)*	= 6.10 %

Previous spawners:

Kelts (downstream) - 99		= 1,857
Tagged kelts (downstream) – 99		= 128 (274)
(109 tagged in '99 & 19 + *x* from '94-98)		
Ratio untagged : tagged (total)	*(351 / 128)*	= 2.74 (5.31)
	or *(1456/274)*	
Over-wintering survival- 98/99		= 17.19% (71.30)
with the recreational catch removed	*(351 / (2296-254)*	
	or (1,456/ (2296-254)	

The following table is a summary of the estimated numbers of previous spawners in small and large categories using previous spawners actual counts and derived figures:

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APPENDIX 7

STOCK: Campbellton River (SFA 4) **Drainage area:** 296 km^2 (accessible)

CONSERVATION REQUIREMENT: 2.916 million eggs (~1480 small salmon) calculated as fluvial area x 2.4 eggs/m^2 and lacustrine area x 368 eggs per hectare.

Year	1993	1994	1995	1996	1997	1998	MIN[1]	MAX[1]
Total returns to the river								
Small	4001	2857	3035	3208	1975	3275	1975	4001
Large	145	191	218	560	321	402	145	560
Recreational harvest (small salmon)								
Retained	316	340	393	463	254	315	23	1547
Released	103	4	47	93	67	250	4	250
Recreational harvest (large salmon)								
Retained	-	-	-	-	-	-	0	63
Released	0	1	1	31	9	8	0	31
Spawners								
Small	3675	2517	2637	2736	1714	2935	1714	3675
Large	145	191	218	557	320	401	145	557
Egg conservation requirement								
% met	311	239	279	304	200	317	200	317
Smolt count	31577	41633	39715	58369	62050	50441	31577	62050
% Sea survival								
(adult return year)		7.2	6.1	7.2	2.3	4.9	2.3	7.2

[1] Min and max are for the period of record since 1974.
[2] Preliminary.

Data and methodology: Smolts were enumerated at a counting fence. Returning adult salmon are enumerated at a fish counting fence with a video camera system. A hook-and-release mortality rate of 10% was used in the calculation of spawning escapements for the years 1993-98. Recreational data for 1997-98 were from the License Stub Return System and are preliminary. Sea survival is corrected to exclude previous spawners in the upstream migration. Previous spawners were estimated in 1998 from survival patterns in previous years. Egg conservation requirement met was calculated using average percent female and average whole weight, 1993-98 due to the low number of samples obtained from the angling fishery.

State of the stock: Conservation requirements were met from 1993 to 1998.

Forecast: No forecast available.

Appendix 8

Campbellton River kelt tagging 1994-99, recorded captures at sea or observation at other rivers.

Year	94	95	96	97	98	99	Total
Number tagged	942	448	484	350	109	573	2906
Kelt migration	2838	1874	1971	2315	351	1857	11206
Returns to other rivers	1	1	2	1	3	4	12
Captures returns at sea	3	1	5	1	0	6	16

Ratio of tagged to untagged	3.85616

		With ratio applied
Percent to other rivers	0.41%	1.59%
Percent at sea	0.55%	2.12%
Total	0.96%	3.72%

Other rivers= Gander R., Exploits R., Loon Bay R.

Captures at sea were mainly by herring nets or at the mouth of the river.